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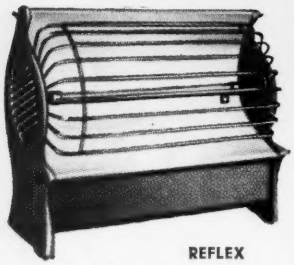

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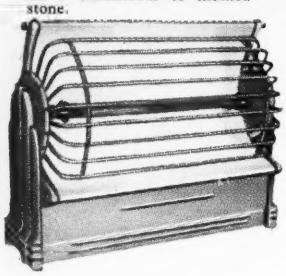

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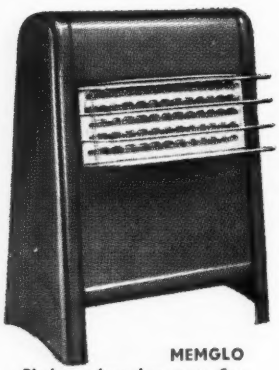

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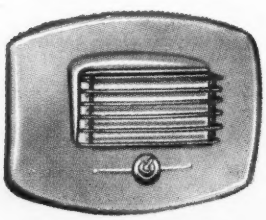

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VOLUME 159 ◇ NUMBER 6

Eighty-Fourth Year of Publication

FRIDAY ◇ PRICE 1s 6d

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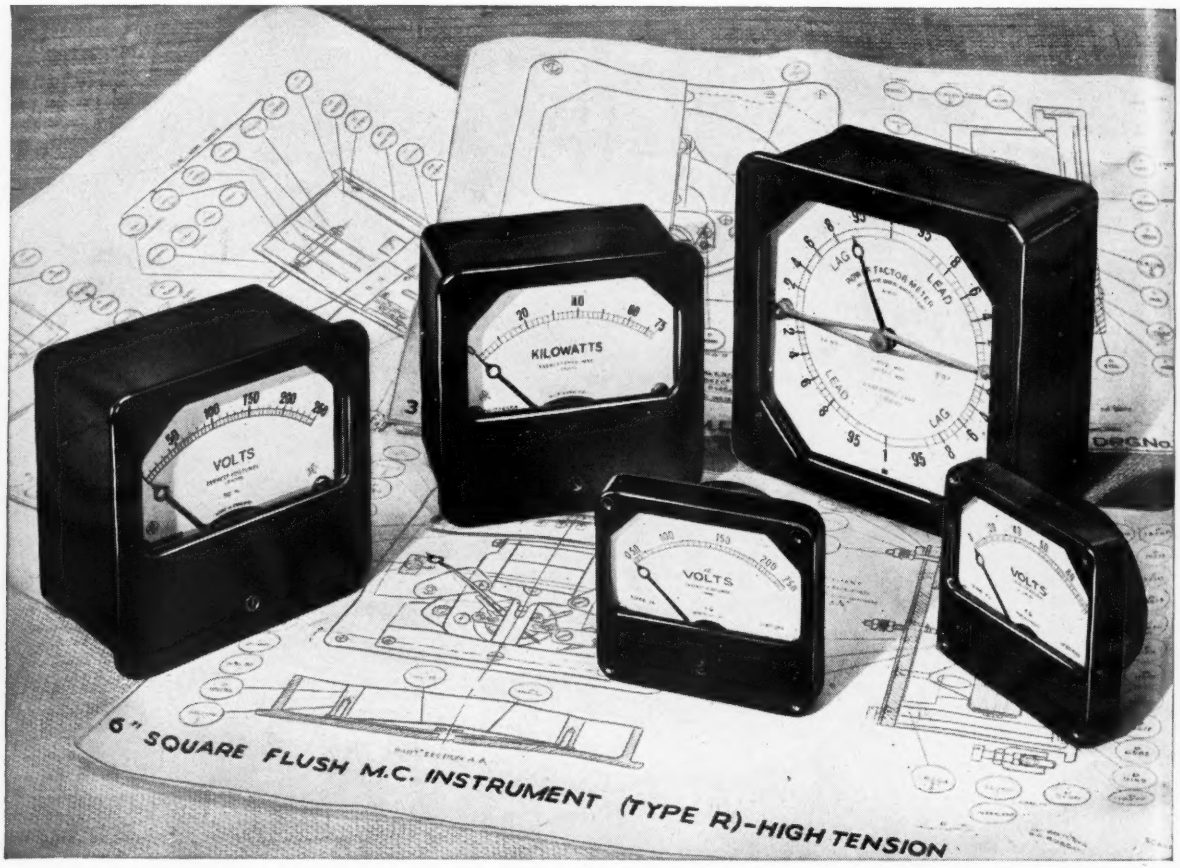

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10 August 1956 Vol. 159 No. 6 Established 1872

B.E.A.M.A. Standards

THE standards published by the National Electrical Manufacturers Association in the U.S.A. are well known and referred to by engineers throughout the world, more so, perhaps, than are the electrical standards issued by the American Standards Association. A new technical publication from the British Electrical and Allied Manufacturers' Association stimulates a memory of B.E.A.M.A. standards. Do they still exist? The answer from the Association provides an interesting comparison of outlook in the two countries. It appears that as long ago as 1916, the B.E.A.M.A. Council of the day decided to support the development, as the national standards body, of the (then) Engineering Standards Committee, later the British Engineering Standards Association and now the British Standards Institution. To implement its policy the B.E.A.M.A. Council decided that new or revised standards developed in B.E.A.M.A. should, preferably, not be published by the Association, but be sent in draft form as proposals to the E.S.C. (as they are nowadays sent to the B.S.I.) and to withdraw existing B.E.A.M.A. standards when British Standards having similar scope were issued.

In the nineteen-twenties B.E.A.M.A. standards were still in general use, although by 1925 a number were listed by title only with the note " superseded by B.S.—." The last major standard initiated and published by the B.E.A.M.A. was the voluminous " Terminal Markings for Electrical Machinery and Apparatus " which first appeared in 1930 and was subsequently taken over by the B.S.I. and published as B.S. 822 in 1938. The withdrawal in recent years of the few remaining B.E.A.M.A. standards was the full implementation of a 40-year-old policy initiated at the time to assist the establishment of one national and independent standards body, a position long since held by the British Standards Institution.

This excursion into the past has been provoked by the recently issued B.E.A.M.A. publication " The Insulation Level of Power Transformers," a comprehensive and authoritative treatment of the subject for its specification by the practical engineer, which is referred to elsewhere in this issue. In 1953 the British Standards Institution decided to revise British Standard No. 171, " Electrical Performance of Transformers for Power and Lighting," and part of the proposals submitted by the B.E.A.M.A. to the B.S.I. covered a new section in the specification to deal with insulation levels and impulse-voltage tests. A major revision of a national standard, however, requires consultation and discussion with all interests and, necessarily, considerable time must elapse before a revised edition of such a comprehensive standard can be completed and published. The B.E.A.M.A. Transformer Section, impressed by the many requests, particularly from overseas, has decided that, in the interim period, some guidance should be made available, in convenient form, of British manufacturers' views on the selection of insulation level and impulse-voltage tests for power transformers.

FOREIGN PLANT TENDERS

Lord Citrine is reported to have told a recent meeting of the National Joint Advisory Council of the Electricity Supply Industry that the Central Electricity Authority had recently received a request from the International General Electric Co. of New York, that they should be allowed to tender for heavy transformers. This had been speedily followed by requests from the Westinghouse International Co. and Allis Chalmers, two other American companies.

As the Central Electricity Authority saw it, there were certain broad national interests involved in this and whilst they had no objection to the principle they thought they ought to consult the Government. The Authority already knew that Electricité de France had been approached by British transformer makers and by makers of other forms of plant for the opportunity of tendering for work for Electricité de France. Electricité de France took the view that they had no objection providing there was reciprocity, permitting French manufacturers to tender for the Central Authority. The Government had replied that this was a policy which they felt should be approved but there were import licences to be negotiated and the particular question could only be determined on the application for a licence.

The Authority had drawn to the Government's notice the question of fair competition and labour costs. In the case of the United States labour standards were higher than in this country but with regard to certain Continental companies the Authority would have to assure themselves that the standards of employment were reasonably comparable with British standards.

This exchange of views will interest British manufacturers who have been awaiting the Government's opinion on the relevant recommendation of the Herbert Committee.

NEW TELEVISION APPLICATION

Another Wellsian prophecy came true on Wednesday of last week when a button pressed in London by the Home Secretary and Minister for Welsh Affairs, Mr. Lloyd-George, not only set in motion Britain's first tonnage oxygen plant at Margam, in South Wales, but also inaugurated a "tour" of the plant by important guests who were sitting in the London board room of the British Oxygen Co., Ltd. This was made possible by the use of the longest television link-up ever to be commissioned by a private company. The technical planning was carried out by Marconi's in co-operation with the G.P.O.

After the inaugural speeches the London audience saw on television monitor screens the plant come into operation and then the viewers took part in a conducted tour of the works. After the oxygen manufacturing process had been described the programme switched to the Margam works of the Steel Company of Wales where the audience saw what happens to the oxygen in the steelworks. Finally, the London audience asked questions about the plant which were answered by experts both in London and South Wales.

The presentation on television of an event of such major importance is a strong pointer to the future, when, without doubt, ever-increasing use will be made of this convenient method of approach. Many people were able to attend at the London end who would have been unable to spare the time to go to South Wales. To attend an opening event of this kind would normally take a Press representative, or any other individual, at least a whole day and even a night away from home, but in this case the whole proceedings were over in a matter of about three hours, which is not unduly inconvenient.

RESTRICTIVE PRACTICES

Before the Parliamentary recess the Restrictive Trade Practices Bill received the Royal Assent and the first Order under the new Act has been made by the Board of Trade. If it receives the approval of Parliament it will come into force on 30th November. The Order will call for the registration of agreements made between manufacturers or their associations imposing conditions of sale and subsequently the parties concerned will be called upon to justify any such agreements before the Restrictive Practices Court which is being set up. Not every agreement will come under scrutiny and there is an "escape clause" in the Act which specifies certain conditions in which a registered agreement will be held not to be against the public interest.

These provisions are contained in the first part of the Act; the second part prohibits collective agreements between suppliers and dealers to maintain resale prices by means of stop lists and discriminatory methods. Price maintenance conditions imposed by an individual manufacturer in respect of its products will still be legal and enforceable in the Courts. Mr. C. F. Mayson reviews the Act in this issue.

ADDITIONAL URGENCY

A new reason for expediting atomic power plans was adduced by Mr. L. J. Callaghan in the House of Commons last week—the possible threat to our Middle East oil supplies arising from the Egyptian Government's nationalisation of the Suez Canal. It would indeed be ironical if the Central Electricity Authority's endeavours to counter the coal shortage by the provision of oil firing at a number of its power stations were negatived by a shortage of oil. Replying to Mr. Callaghan's suggestion that the nuclear power programme should be accelerated, the Minister of Fuel and Power agreed that it was desirable that the present programme, which he described as a "minimum" one, should be accelerated and expanded as far as was practicable. He considered that more could be done than had been thought possible at first, but further developments would have to await examination of the plans for the first stations which were due to be submitted in the autumn. We can only hope that the plans will show that the type of station decided upon will be able to produce power at a reasonable price, even though later designs will be superior. While it is necessary to take a long view, there is an urgency about the matter which forbids delay until greater perfection is attained in the generation of power from nuclear fission (or fusion).

High-Speed Induction Motors

Some Recent Developments in Design

By W. HILL, A.M.C.T., A.M.I.E.E., and J. K. VOSE, B.Sc., A.M.I.E.E.*

BEFORE the last war there had been an increasing tendency towards the use of high-speed motors either direct-coupled or driving through speed-reducers. The trend since the end of that war has been even more marked and has probably been accelerated by the desirability, technical or economic, of reducing the physical size of driven machinery, e.g. centrifugal pumps.

The 3,000 r.p.m., or in the largest sizes 1,500 r.p.m., motor is commonly used to drive boiler-feed and booster pumps in power stations and on board ships; oil, water and process pumps in oil refineries; and boiler-feed and drainage pumps at collieries. Other examples of the type of drive for which 3,000 r.p.m. motors are required are compressors in gasworks and refineries, and high-frequency generators in the metallurgical industry and for industrial heat treatment.

The mechanical and electrical design of induction motors, which are the commonest form of driving unit, is under continual development to meet the constant demand for more powerful and still more reliable high-speed motors which must have a better performance and a much lower noise level than was acceptable even a decade ago.

Electrical Performance

Though the effects of mechanical changes are more apparent to the eye, the improvements in electrical design have resulted in many worthwhile benefits in performance. The demand for reduced starting times and starting currents has been met without significant reduction in overload capacity or power factor. Reduced losses give improved efficiencies and enable outputs to be raised.

The mechanical robustness of the windings is constantly being improved as new materials become available: terylene for slot insulation, and a synthetic enamel coating under the usual cotton or braided-glass conductor coverings have been used with success. The bracing of end-windings to withstand the mechanical forces resulting from magnetic stresses during direct-on-line starting has also received much attention.

The largest possible air gaps are used to reduce the stray-load losses and heating; magnetic noise is also kept to a minimum. Uninsulated rotor bars driven into tightly-fitting slots ensure that maximum freedom from bar vibration is obtained. Balancing of high-speed motors must be very carefully done and final balancing is carried out under power with the rotors running in their own bearings and stators.

Considerable control over the performance of the motor can be exercised, when shrink or retaining rings are fitted over the rotor end-rings, by suitable choice of the material from which they are made. Mechanical, electrical, and magnetic properties are all considered in making the final decision.

Test facilities for the full checking of all performance guarantees and calculated design data are essential in providing the design department with the necessary information on which future development can be based. Both running and starting performance must be studied;

* Metropolitan-Vickers Electrical Co., Ltd.

Fig. 1.—Oscillogram of speed-torque test. Machine run up to speed from reversed rotation on 2,900 V (double-cage rotor, non-skewed slots)

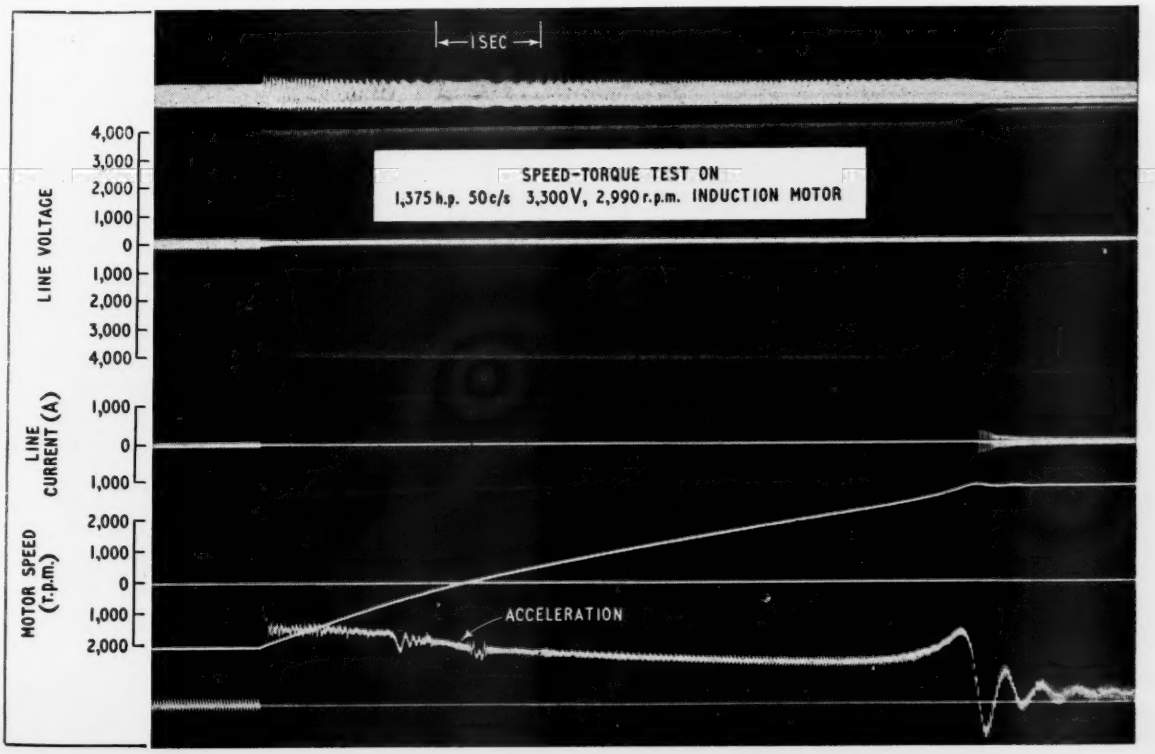


Fig. 1 shows the speed-torque oscillogram of a 1,375 h.p. boiler-feed pump motor. The oscillogram shows that the motor was reversed at full voltage through the standstill position and run up to full speed, taking about six seconds. This method avoids sub-transient currents at standstill and allows the real starting current to be measured more easily.

Construction and Appearance

Changes in construction have greatly altered the appearance of high-speed motors, particularly of the protected and totally-enclosed closed-air-circuit with water-cooled air-cooler types. Where possible, advantage has been taken of these changes to produce a cleaner "line," though no attempt has been made to alter the appearance of a component without regard to its function.

A number of current designs are shown in Figs. 2-6 and it will be seen that some measure of success has been achieved. The provision of auxiliary oil pumps for the forced lubrication of bearings has influenced the appearance considerably and it is worth noting that the care expended in making the associated pipework, gauges, and other ancillary apparatus as unobtrusive as possible has also resulted in a greatly reduced vulnerability of these components.

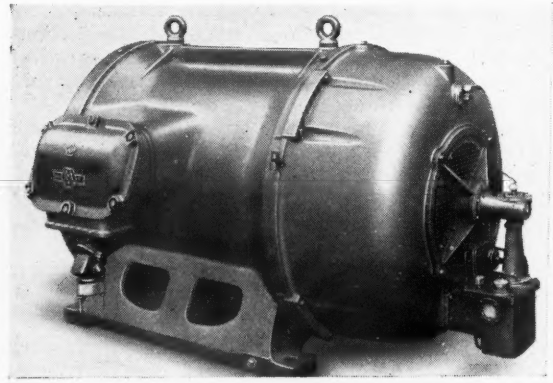


Fig. 2.—400 h.p. 2,950 r.p.m. flameproof totally-enclosed fan-cooled motor with ball and roller bearings oil-lubricated by the circulating system

The totally-enclosed fan-cooled design is still the most popular enclosure for high-speed motors largely because of the demand for flameproof motors of this type for the mining and petroleum industries. For power station auxiliaries there has been a marked trend towards the drip-proof or, in the larger sizes, the totally-enclosed closed-air-circuit machine with water-cooled air cooler. It is not always appreciated that the fitting of such a cooler still allows the same output from the machine for a given temperature rise as from a similar drip-proof motor.

For certain applications there is sometimes a desire to dispense with the water cooler and use an air-to-air cooler instead; this is bound to reduce the maximum rating of the frame for a given temperature rise but the machine is then independent of a water supply.

The ventilating air is circulated by either one or two unidirectional centrifugal or propeller type fans. Both types are carefully designed to give the required air quantity with the lowest possible loss and noise. Propeller fans have a minimum number of aerofoil blades and are provided with rotating shrouds rather than stationary ones to make use of the higher generated pressure head of air.

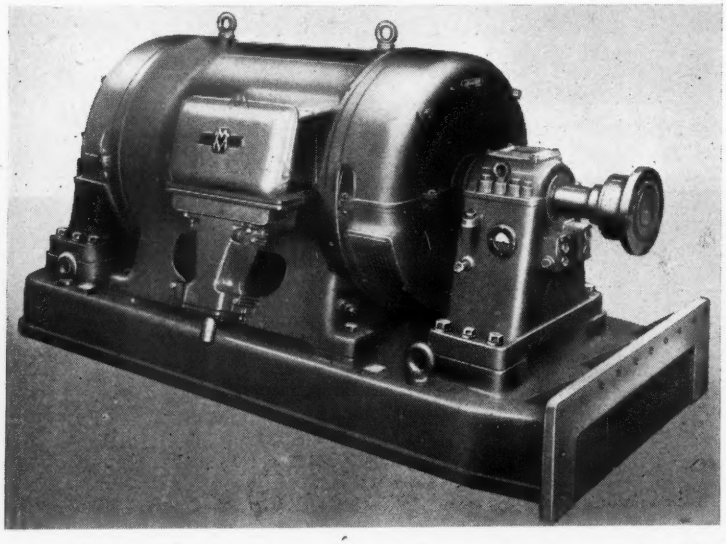
Both axial and double-ended ventilation systems are in use. The latter has some advantages for the larger sizes of machine: one advantage results from the human ear adding noise intensities logarithmically. This makes the noise from two fans, each providing half the air quantity, less than that of one fan producing the total quantity. Another advantage lies in the possibility of providing cooling air to the vicinity of both driving and non-driving end bearings.

Considerations of this kind emphasise the fact that the design of these large motors demands a rigorous integration of each electrical or mechanical detail into the whole.

Bearings and Lubrication

The best electrical performance would be of no avail if the bearings did not continue to support the rotor satisfactorily. The correct type and design of the bearings is, therefore, of paramount importance in this type of machine.

The choice between oil-lubricated ball and roller bearings and plain sleeve bearings is not always just a



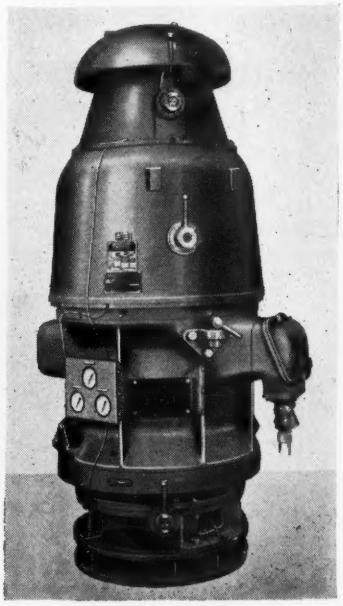


Fig. 3.—700 h.p. 2,950 r.p.m. drip-proof motor with ring-oiled (water-cooled) pedestal sleeve bearings. Fig. 4 (right).—Flameproof totally-enclosed fan-cooled vertical motor with oil-lubricated roller guide bearings and air-cooled Michell thrust bearing

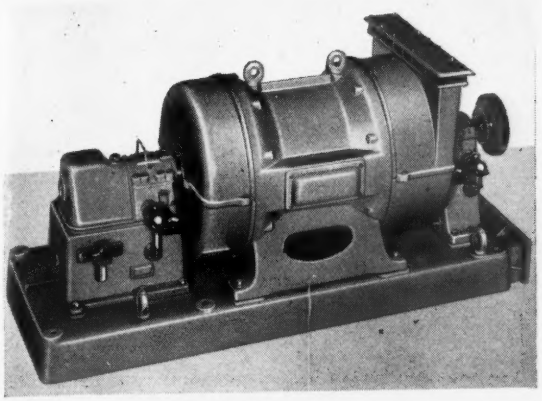


Fig. 5.—1,800 h.p. 2,950 r.p.m. drip-proof motor with pedestal sleeve bearings flow-lubricated by gear-driven pump

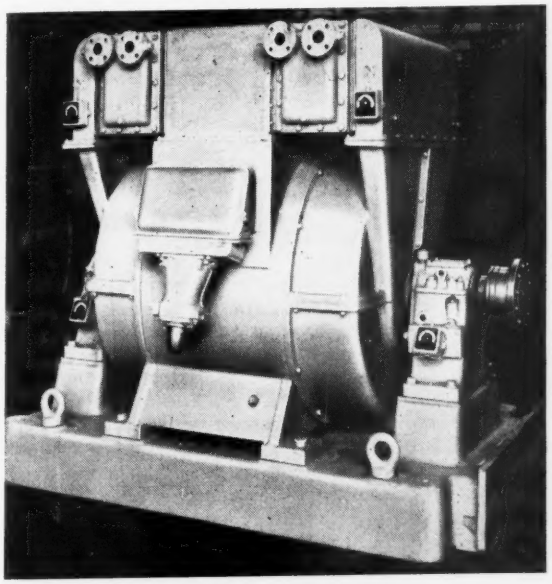
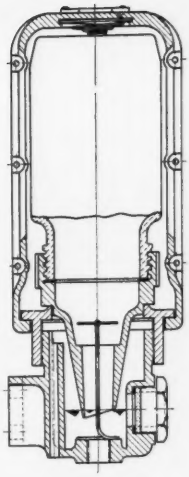


Fig. 6.—2,000 h.p. 2,950 r.p.m. totally-enclosed closed-air-circuit machine with water-cooled air cooler fitted with ring-oiled (water-cooled) pedestal sleeve bearings

question of size and speed. In flameproof machines, for instance, certain maximum clearances between rotating and stationary seals must not be exceeded in service. These are more easily maintained with ball and roller bearings.

Consider horizontal machines with rolling bearings. For high-speed ball and roller bearings of any size, oil has supplanted grease because grease has a short effective life under these conditions and is difficult to replenish satisfactorily. Oil is easily replenished or renewed and the mist from the movement of the rolling elements through the oil effectively lubricates the bearing surfaces.

Two forms of oil lubrication for ball and roller bearings are available: the "constant level" and the "circulating" systems. The need to keep the oil temperature below that at which oxidation becomes too rapid determines which of the two is used in a particular case. Both systems are basically of the "bath" type: the lubricant is conveyed to the working surfaces by the balls or rollers which dip into the oil bath at the lowest point of their path. The bearing housing is so constructed that it contains the oil bath in a central portion on either side of



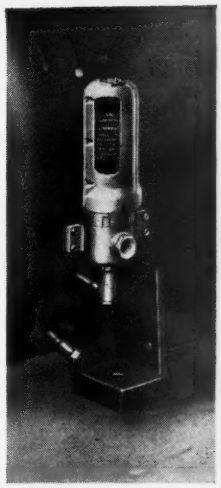


Fig. 7.—Section through constant level lubricator and one fitted to the yoke of a flameproof totally-enclosed fan-cooled motor

which are chambers vented to atmosphere by large diameter pipes and breather fittings which prevent fan suction from drawing oil out of the bearing housing. The bath is maintained at a constant level above the track surface, determined by the height of a weir or overflow hole, either by a "constant level" lubricator or, in the "circulating" system, by a small plunger pump. The "constant level" lubricator (Fig. 7) uses a principle, long employed in chicken feeders, to control the flow of oil from an inverted reservoir which has no communication with atmosphere other than that provided through the opening of its mouth by a fall in the oil level in the associated apparatus. Once adjusted the device is self-regulating, has little to go wrong and permits the oil level to be inspected readily.

The "circulating" system employs a multi-plunger pump, driven from the motor at a low speed through a worm reduction gear box, to supply metered quantities of filtered oil to the motor bearings and to the gear box. As the larger part of the service life of the oil is spent in the tank where temperature is comparatively low and where there is little agitation, the oxidation rate of the oil is very low. The "circulating" system is, therefore, used where the simple "constant level" system would not be expected to give satisfactory service owing to the nature of the conditions.

"Jet" or "spray" systems have been and are used where the churning of oil would generate too much heat. They are unnecessarily complicated for normal use and failure of any of the auxiliary apparatus requires an immediate shut-down as there is no emergency reserve of oil in the bearing housings.

In the case of horizontal machines with plain bearings, the smaller sizes of bearing have oil-ring lubrication, a water cooler or water jacket being used where necessary to keep the oil temperature within reasonable limits. The larger bearings cannot be adequately lubricated by oil rings alone and for these flow lubrication is adopted. One oil ring is, however, retained for starting and emergency use. Oil is taken from the tank through a strainer by a gear pump and forced through a full-flow edge type filter and a pressure relief valve to the flow control valve mounted on the top of the bearing housing or at the side of the oil tank. A weir retains enough oil for starting and shutting-down in emergency. The oil returns to the tank through large diameter pipes fitted with oil flow inspection windows. Where necessary, a cooler may be installed in the system

to reduce the oil temperature under conditions of high ambient temperature. The plain bearings themselves are of the sleeve type, split on the horizontal centre-line and lined with white metal.

On vertical machines with rolling bearings, oil lubrication has been found to provide a very good answer to the difficulties hitherto encountered of providing effective grease lubrication for the bearings of vertical shaft high-speed motors.

Fig. 8 shows a section through a typical bearing assembly. Oil is supplied by a simple pump which consists of a hollow cylinder open at the lower end and with a slight outward taper of the inner walls. This system of lubrication can equally well be applied to ball or roller bearings. Ball bearings of either the duplex angular contact type or of the deep groove type may be used alone, or in conjunction with a roller guide bearing, at one end of the machine. A roller bearing is fitted at the other end.

Vertical machines with plain bearings commonly employ bearings of the Michell type with tilting pads to take the thrusts. They are mounted on the top of the motor (see Fig. 4) so that the shaft system of the motor, and frequently of the pump also, hangs from the bearing. Cooling may be by natural convection, by water coolers inside the bearing housing, or by radiator coils or specially finned

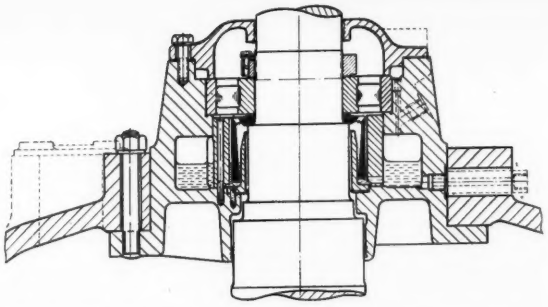
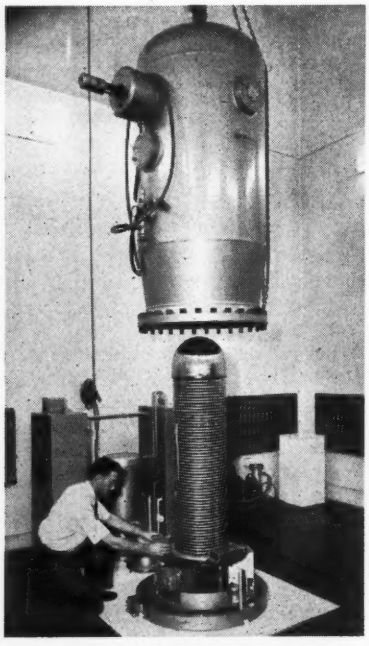


Fig. 8.—The oil-lubricated bearing assembly of a flameproof totally-enclosed fan-cooled vertical motor

casings in the inlet stream of air to the motor. The bearings are generally designed for one direction of rotation only as this enables a smaller and more efficient bearing to be used. The design of bearings of the Michell type permits a rapid build-up of a fluent film between the stationary pads and the rotating collar, so enabling heavy loads to be supported. The design is thus eminently suited to vertical motors in which heavy pump thrusts must often be encountered.

New Particle Accelerator

ON 1st August Sir John Cockcroft officiated at the switching-on ceremony of a new American-built two million volt Van de Graaff electrostatic particle accelerator which has been installed by Standard Telecommunication Laboratories, Ltd. (an associate of Standard Telephones & Cables, Ltd.) at Enfield. This machine, which has cost about £50,000, is essentially for generating intense and highly penetrating beams of electrons and other atomic particles and directing them at a target. It may be regarded as a basic tool of modern nuclear physics and it is particularly useful in industrial research since it produces radiations which can be controlled readily and measured accurately. In general, it offers a safer source of radiation than either radio-active isotopes or reactor sources since it is only active when it is being operated and can be switched off completely at will.



New 2 MV Van de Graaff particle accelerator installed at Enfield

The electron beams so generated can be used for a great variety of purposes ranging over such fields as cancer treatment, the sterilisation of foodstuffs, radiographic inspection of metal castings, and effecting structural or chemical changes in materials. It is in this last field that the immediate interest of the company lies. Thus, by way of example, the characteristics of polythene can be extensively modified by irradiating it in an electron beam. In particular, the melting point can be raised very considerably and components using the modified polythene can be operated at higher temperatures with consequent economies. The effects on a range of similar materials are now also being investigated.

Research Reactor

THE United Kingdom Atomic Energy Authority has asked the A.E.I.-John Thompson Nuclear Energy Co., Ltd., to start preliminary work on the design and construction of a research reactor at the Atomic Weapons Research Establishment. The reactor will use light water as a moderator and coolant, and will be designed for operating at power levels up to 5 MW. Discussions on design and layout, particularly concerning the experimental facilities to be provided, have been proceeding for the past six months.

The reactor is fundamentally the same as that being built for the Associated Electrical Industries Research Laboratories at Aldermaston Court, but the experimental facilities have been altered to suit the special requirements of the Weapons Establishment. Cooling will be by air-blast coolers in the primary circuit.

Certain constructional items associated with reactors, such as the biological shield and the reactor foundation, will be undertaken by the Ministry of Works for the U.K.A.E.A. The delivery of the equipment to the Authority's site is expected to be completed within twelve months. This reactor will be used to obtain fundamental data required in the fields of weapons development and reactors for military purposes.

MATRICES–1

The Algebraic Manipulations Involved

By JOHN WEBB, M.Sc.

THIS is the first of two articles which are intended to be of assistance to engineers and to others who seek a simple explanation of matrix algebra. The manipulation and the application of matrices is developed mostly along non-general lines, use being made throughout the articles of simple (and often purely hypothetical) equations.

The solution of a large number of simultaneous equations presents the mathematician not only with the difficulty of computation but also with the tedium of writing down a large number of terms. The notation of matrices is to be regarded as a mathematical shorthand which has been developed to reduce this tedium.

Thus the general set of m equations in n unknowns is

$$\left.\begin{aligned} a_{11}x_1 + a_{12}x_2 + \ldots\ldots + a_{1n}x_n &= y_1 \\ a_{21}x_1 + a_{22}x_2 + \ldots\ldots + a_{2n}x_n &= y_2 \\ a_{31}x_1 + a_{32}x_2 + \ldots\ldots + a_{3n}x_n &= y_3 \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots & \\ a_{m1}x_1 + a_{m2}x_2 + \ldots\ldots + a_{mn}x_n &= y_m \end{aligned}\right| \quad \ldots\ldots (1)$$

These may be written in the following contracted form

$$\begin{bmatrix} a_{11} & a_{12} & \ldots. & a_{1n} \\ a_{21} & a_{22} & \ldots. & a_{2n} \\ a_{31} & a_{32} & \ldots. & a_{3n} \\ \ldots\ldots\ldots\ldots & & & \\ a_{m1} & a_{m2} & \ldots. & a_{mn} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ \ldots \\ x_n \end{bmatrix} = \begin{bmatrix} y_1 \\ y_2 \\ y_3 \\ \ldots \\ y_m \end{bmatrix} \quad \ldots\ldots (2)$$

in which the coefficients are seen to have become detached from their respective variables.

An array of coefficients such as

$$\begin{bmatrix} a_{11} & a_{12} & \ldots. & a_{1n} \\ a_{21} & a_{22} & \ldots. & a_{2n} \\ a_{31} & a_{32} & \ldots. & a_{3n} \\ \ldots\ldots\ldots\ldots & & & \\ a_{m1} & a_{m2} & \ldots. & a_{mn} \end{bmatrix} = \mathbf{a} = [a_{ij}]$$

is known as a matrix and could be described simply as a set of numbers (known as elements) arranged in m rows and n columns. By inspection it is seen that the element a_{32} belongs to the 3rd row and the 2nd column, in general then a_{ij} belongs to the i^{th} row and the j^{th} column. The significance of the double suffix should now be obvious. Again by inspection of equation 1, it is seen that the coefficient a_{ij} refers to the variable x_j and not to x_i. Thus there is a term $a_{32}x_2$ but no such term as $a_{32}x_3$ in equation 1.

The order of a matrix is said to be m by n (written m × n) where m is the number of rows and n is the number of columns in the matrix.

Some possible matrices with their respective orders are listed below. The reader will note that square brackets are an essential part of the matrix notation and that these are omitted only when the whole matrix is denoted by a single symbol such as **a** or **b**

$$\begin{bmatrix} 2 & 4 & 6 & 1 \\ 5 & 0 & 1 & 4 \\ 4 & 3 & 7 & 3 \end{bmatrix}$$ is a 3 × 4 matrix

$$\begin{bmatrix} a_1 & b_1 & c_1 & d_1 \\ a_2 & b_2 & c_2 & d_2 \\ a_3 & b_3 & c_3 & d_3 \\ a_4 & b_4 & c_4 & d_4 \end{bmatrix}$$ is a 4 × 4 square matrix

$[x_1\ x_2\ x_3]$ is a 1 × 3 or a row matrix

$$\begin{bmatrix} y_1 \\ y_2 \\ y_3 \\ y_4 \end{bmatrix}$$ is a 4 × 1 or a column matrix.

The column matrix absorbs much more vertical than horizontal printing space so that for economy the alternative notation, wherein curled brackets replace square brackets, is often employed. The elements are written down horizontally.

Thus $\begin{bmatrix} y_1 \\ y_2 \\ y_3 \\ y_4 \end{bmatrix}$ is often written $\{y_1\ y_2\ y_3\ y_4\}$

Matrix algebra may be regarded as an extension of ordinary algebra. It originated in the last century when it was suggested that a matrix could be regarded as an operator. Thus in equation 2, which may be written in the form

$$\mathbf{a}\ .\ \mathbf{x} = \mathbf{y}$$

a may be said to operate upon **x** to yield **y**, just as in simple algebra a operates upon x to give h in the equation

$$a\ x = h$$

Having suggested that the matrix could be thought of as an operator, Cayley went on to discover the rules governing the addition and multiplication of matrices.

Addition of Matrices

Consider the hypothetical equations

$$3x_1 + 4x_2 = p_1 \qquad 2x_1 - 5x_2 = p_2$$

and

$$-2x_1 + x_2 = q_1 \qquad 4x_1 + 3x_2 = q_2$$

these may be written in matrix notation

$$\begin{bmatrix} 3 & 4 \\ 2 & -5 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} p_1 \\ p_2 \end{bmatrix}, \quad \begin{bmatrix} -2 & 1 \\ 4 & 3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} q_1 \\ q_2 \end{bmatrix}$$

Suppose now that $p_1 + q_1 = r_1$, $p_2 + q_2 = r_2$

it follows that

$$(3-2)\,x_1 + (4+1)\,x_2 = r_1$$
$$(2+4)\,x_1 + (-5+3)\,x_2 = r_2$$

which can be written

$$\begin{bmatrix} 1 & 5 \\ 6 & -2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} r_1 \\ r_2 \end{bmatrix}$$

We can therefore write

$$\begin{bmatrix} 3 & 4 \\ 2 & -5 \end{bmatrix} + \begin{bmatrix} -2 & 1 \\ 4 & 3 \end{bmatrix} = \begin{bmatrix} 1 & 5 \\ 6 & -2 \end{bmatrix}$$

In general two or more matrices of the same order may be added by adding together their corresponding elements and by setting down these sums in the corresponding positions in the sum matrix.

A few examples of matrix addition are given below

(i) $$\begin{bmatrix} 6 & 0 & 5 \\ 3 & -1 & -2 \\ 4 & -3 & 0 \end{bmatrix} + \begin{bmatrix} -2 & 1 & -3 \\ 1 & 2 & 2 \\ 3 & -1 & 1 \end{bmatrix} = \begin{bmatrix} 4 & 1 & 2 \\ 4 & 1 & 0 \\ 7 & -4 & 1 \end{bmatrix}$$

(ii) $$\begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix} + \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} = \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix}$$

A matrix in which all the elements are zero is called a zero or null matrix

(iii) $$\begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix} + \begin{bmatrix} z_1 \\ z_2 \\ z_3 \end{bmatrix} = \begin{bmatrix} y_1 + z_1 \\ y_2 + z_2 \\ y_3 + z_3 \end{bmatrix}$$

Scalar Multiplication of Matrices

If the variables y_1 and y_2 are given by

$$y_1 = 6x_1 - 7x_2 + 4x_3$$
$$y_2 = 4x_1 + 3x_2 - 5x_3$$

and if $w_1 = 3y_1$ and $w_2 = 3y_2$ then

$$w_1 = 18x_1 - 21x_2 + 12x_3$$
$$w_2 = 12x_1 + 9x_2 - 15x_3$$

from which it follows that

$$3\begin{bmatrix}6 & -7 & 4\\ 4 & 3 & -5\end{bmatrix} = \begin{bmatrix}18 & -21 & 12\\ 12 & 9 & -15\end{bmatrix}$$

In general terms $a\,\mathbf{a} = [aa_{ij}]$

Multiplication of Matrices

Consider the two sets of equations

$$p_1 = 3x_1 + 4x_2 \qquad q_1 = 4p_1 + 6p_2$$
$$p_2 = 2x_1 + 5x_2 \qquad q_2 = 2p_1 + p_2$$
$$q_3 = 3p_1 + 2p_2$$

by substitution we obtain

$$q_1 = (4 \times 3 + 6 \times 2)x_1 + (4 \times 4 + 6 \times 5)x_2$$
$$q_2 = (2 \times 3 + 1 \times 2)x_1 + (2 \times 4 + 1 \times 5)x_2$$
$$q_3 = (3 \times 3 + 2 \times 2)x_1 + (3 \times 4 + 2 \times 5)x_2$$

The detached co-efficients form the matrix

$$\begin{bmatrix}4 \times 3 + 6 \times 2 & 4 \times 4 + 6 \times 5\\ 2 \times 3 + 1 \times 2 & 2 \times 4 + 1 \times 5\\ 3 \times 3 + 2 \times 2 & 3 \times 4 + 2 \times 5\end{bmatrix}$$

which may be regarded as the product of the two matrices

$$\begin{bmatrix}4 & 6\\ 2 & 1\\ 3 & 2\end{bmatrix} \text{ and } \begin{bmatrix}3 & 4\\ 2 & 5\end{bmatrix}, \text{ say } \mathbf{b} \text{ and } \mathbf{a}.$$

In ordinary algebra if $p = ax$ and $q = bp$ then we write $q = bax$, after substituting for p. Since multiplication in ordinary algebra is commutative we could equally well write $q = abx$.

In matrix algebra multiplication is non-commutative and in general the matrix product **b.a** is not equal to the matrix product **a.b.** This complication will call for clear thinking if errors are to be avoided.

The two sets of equations with which we started can be written

$$\mathbf{p} = \mathbf{ax} \qquad \mathbf{q} = \mathbf{bp}$$
$$\therefore \quad \mathbf{q} = \mathbf{bax}$$

It must be emphasised that the matrix product here is definitely **ba** and not **ab**. With this point heavily underlined we will now look at the product again in search of the rule governing the elements in the product matrix.

$$\begin{bmatrix}4 & 6\\ 2 & 1\\ 3 & 2\end{bmatrix}\begin{bmatrix}3 & 4\\ 2 & 5\end{bmatrix} = \begin{bmatrix}4\times3+6\times2 & 4\times4+6\times5\\ 2\times3+1\times2 & 2\times4+1\times5\\ 3\times3+2\times2 & 3\times4+2\times5\end{bmatrix}$$
$$= \begin{bmatrix}24 & 46\\ 8 & 13\\ 13 & 22\end{bmatrix}$$

Firstly the number of columns in **b** must be equal to the number of rows in **a** if multiplication is to be attempted. The reason for this will be manifest if the initial equations are examined. Suppose that the equations for q_n include a term in p_3 while there remain only 2 equations for p_n namely for p_1 and p_2 then obviously no substitution for p_3 is possible. It is sometimes necessary to look in this way at the actual equations so as to gain a simple interpretation of a matrix operation.

Let us look at the element in the 2nd row and 1st column of the matrix product, that is, at the element $(2\times3+1\times2)$.

This is obtained by multiplying the 2nd row 1st column element in **b** and the 1st row 1st column element in **a**, and adding to this, the product of the 2nd row 2nd column element in **b** and the 2nd row 1st column element in **a**. This sounds complicated and a general mathematical statement such as $\sum_{k=1}^{n} b_{ik}\,a_{kj}$, giving the value of the i^{th} row j^{th} column element in the product matrix may not at first sight appear to make matters any easier. The reader is strongly advised to invent equations and to obtain the product matrices by substitution in each case, if he experiences any difficulty at this stage. To summarise, we multiply rows into columns.

Problems Involving the Multiplication of Matrices

The reader should work through these problems before proceeding further.

(i) $\begin{bmatrix}2 & 1\\ 1 & 2\end{bmatrix}\begin{bmatrix}3 & 1\\ 4 & 2\end{bmatrix} = \begin{bmatrix}(2\times3+1\times4) & (2\times1+1\times2)\\ (1\times3+2\times4) & (1\times1+2\times2)\end{bmatrix} = \begin{bmatrix}10 & 4\\ 11 & 5\end{bmatrix}$

(ii) $\begin{bmatrix}3 & 1\\ 4 & 2\end{bmatrix}\begin{bmatrix}2 & 1\\ 1 & 2\end{bmatrix} = \begin{bmatrix}(3\times2+1\times1) & (3\times1+1\times2)\\ (4\times2+2\times1) & (4\times1+2\times2)\end{bmatrix} = \begin{bmatrix}7 & 5\\ 10 & 8\end{bmatrix}$

From these two products it is seen that in general **ab** is not equal to **ba.**

(iii) $\begin{bmatrix}2 & 1 & 0\\ 1 & 3 & 2\\ 0 & 2 & 3\end{bmatrix}\begin{bmatrix}2\\ 0\\ 1\end{bmatrix} = \begin{bmatrix}(2\times2+1\times0+0\times1)\\ (1\times2+3\times0+2\times1)\\ (0\times2+2\times0+3\times1)\end{bmatrix} = \begin{bmatrix}4\\ 4\\ 3\end{bmatrix}$

(iv) $\begin{bmatrix}2\\ 0\\ 1\end{bmatrix}\begin{bmatrix}2 & 1 & 0\\ 1 & 3 & 2\\ 0 & 2 & 3\end{bmatrix}$ cannot be evaluated since the number of columns in the first matrix is not equal to the number of rows in the second matrix.

(v) $\begin{bmatrix}1 & 0 & -2\\ 2 & -4 & 5\end{bmatrix}\begin{bmatrix}2 & 1\\ -1 & 0\\ 1 & 2\end{bmatrix} = \begin{bmatrix}0 & -3\\ 13 & 12\end{bmatrix}$

(vi) $[2\ \ 1\ \ 3]\ \ \{2\ \ 0\ \ 4\} = [16]$

(vii) $\{2\ \ 0\ \ 4\}\ \ [2\ \ 1\ \ 3] = \begin{bmatrix}4 & 2 & 6\\ 0 & 0 & 0\\ 8 & 4 & 12\end{bmatrix}$

The product matrix $\mathbf{c} = \mathbf{ab}$ is obtained by pre-multiplying **b** by **a** or by post-multiplying **a** by **b**. The terms pre-multiplication and post-multiplication are necessary because matrix multiplication (as can be seen from the above problems) is not commutative, so that it is imperative that the terminology should leave no doubt as to what is being multiplied by what. It can be shown that, when three matrices **a, b** and **c** are multiplied together, the product

$$\mathbf{a(bc)} = \mathbf{(ab)c} \quad \text{(See next example)}$$

(viii) $\begin{bmatrix}3 & 2\\ 0 & 1\end{bmatrix}\begin{bmatrix}0 & 1\\ 4 & 2\end{bmatrix}\begin{bmatrix}2 & 0\\ 3 & 1\end{bmatrix} = \begin{bmatrix}3 & 2\\ 0 & 1\end{bmatrix}\begin{bmatrix}3 & 1\\ 14 & 2\end{bmatrix} = \begin{bmatrix}37 & 7\\ 14 & 2\end{bmatrix}$

$\begin{bmatrix}3 & 2\\ 0 & 1\end{bmatrix}\begin{bmatrix}0 & 1\\ 4 & 2\end{bmatrix}\begin{bmatrix}2 & 0\\ 3 & 1\end{bmatrix} = \begin{bmatrix}8 & 7\\ 4 & 2\end{bmatrix}\begin{bmatrix}2 & 0\\ 3 & 1\end{bmatrix} = \begin{bmatrix}37 & 7\\ 14 & 2\end{bmatrix}$

The Scalar Matrix

Consider the scalar transformation in 3 dimensions

$$y_1 = ax_1$$
$$y_2 = ax_2$$
$$y_3 = ax_3$$

in which the variables are related by a constant scale factor a. The coefficients of x_j may be written in matrix form as follows

$$\begin{bmatrix}a & 0 & 0\\ 0 & a & 0\\ 0 & 0 & a\end{bmatrix}$$

Such a matrix is called a scalar matrix.

A further development in the code of matrices allows us to replace zero by a dot, so that the matrix may be written

$$\begin{bmatrix}a & . & .\\ . & a & .\\ . & . & a\end{bmatrix}$$

It has already been seen under the heading of scalar multiplication that

$$[\alpha\, a_{ij}] = \alpha \mathbf{a}$$

from which it follows that

$$\begin{bmatrix} \alpha & . & . \\ . & \alpha & . \\ . & . & \alpha \end{bmatrix} = \alpha \begin{bmatrix} 1 & . & . \\ . & 1 & . \\ . & . & 1 \end{bmatrix}$$

where $\begin{bmatrix} 1 & . & . \\ . & 1 & . \\ . & . & 1 \end{bmatrix}$ is the unit matrix denoted usually by **I**. It is profitable at this stage to investigate some of the properties of the unit matrix.

$$\begin{bmatrix} 1 & . \\ . & 1 \end{bmatrix} \begin{bmatrix} 1 & . \\ . & 1 \end{bmatrix} = \begin{bmatrix} 1 & . \\ . & 1 \end{bmatrix}$$

or $\mathbf{I}^2 = \mathbf{I}$

$$\begin{bmatrix} 1 & . & . \\ . & 1 & . \\ . & . & 1 \end{bmatrix} \begin{bmatrix} 2 & . & 1 \\ 3 & 2 & 1 \\ 1 & 2 & 3 \end{bmatrix} = \begin{bmatrix} 2 & . & 1 \\ 3 & 2 & 1 \\ 1 & 2 & 3 \end{bmatrix}$$

or $\mathbf{Ia} = \mathbf{a}$

$$\begin{bmatrix} 4 & . & . \\ . & 4 & . \\ . & . & 4 \end{bmatrix} \begin{bmatrix} 1 & 3 & 2 \\ 2 & 4 & 1 \\ 4 & 1 & . \end{bmatrix} = \begin{bmatrix} 4 & 12 & 8 \\ 8 & 16 & 4 \\ 16 & 4 & . \end{bmatrix} = 4 \begin{bmatrix} 1 & 3 & 2 \\ 2 & 4 & 1 \\ 4 & 1 & . \end{bmatrix}$$

$$\begin{bmatrix} 1 & 3 & 2 \\ 2 & 4 & 1 \\ 4 & 1 & . \end{bmatrix} \begin{bmatrix} 4 & . & . \\ . & 4 & . \\ . & . & 4 \end{bmatrix} = \begin{bmatrix} 4 & 12 & 8 \\ 8 & 16 & 4 \\ 16 & 4 & . \end{bmatrix} = 4 \begin{bmatrix} 1 & 3 & 2 \\ 2 & 4 & 1 \\ 4 & 1 & . \end{bmatrix}$$

Thus $\alpha\, \mathbf{Ia} = \mathbf{a}\, \alpha\, \mathbf{I} = \alpha\, \mathbf{a}$, provided that the orders of the two matrices are such as to permit of both pre- and post-multiplication.

The special matrix in which all the elements except those on the leading diagonal are zero and in which in general the diagonal elements are not equal is called a quasi-scalar matrix or a diagonal matrix.

Some of the properties of such matrices are illustrated below.

$$\begin{bmatrix} 2 & . & . \\ . & 1 & . \\ . & . & 3 \end{bmatrix} \begin{bmatrix} 4 & . & . \\ . & 2 & . \\ . & . & 1 \end{bmatrix} = \begin{bmatrix} 8 & . & . \\ . & 2 & . \\ . & . & 3 \end{bmatrix}$$

$$\begin{bmatrix} 4 & . & . \\ . & 2 & . \\ . & . & 1 \end{bmatrix} \begin{bmatrix} 2 & . & . \\ . & 1 & . \\ . & . & 3 \end{bmatrix} = \begin{bmatrix} 8 & . & . \\ . & 2 & . \\ . & . & 3 \end{bmatrix}$$

From this it follows that for two diagonal matrices, $\mathbf{ab} = \mathbf{ba}$

$$\begin{bmatrix} 1 & . & . \\ . & 2 & . \\ . & . & 3 \end{bmatrix} \begin{bmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{bmatrix} = \begin{bmatrix} a_1 & b_1 & c_1 \\ 2a_2 & 2b_2 & 2c_2 \\ 3a_3 & 3b_3 & 3c_3 \end{bmatrix}$$

$$\begin{bmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{bmatrix} \begin{bmatrix} 1 & . & . \\ . & 2 & . \\ . & . & 3 \end{bmatrix} = \begin{bmatrix} a_1 & 2b_1 & 3c_1 \\ a_2 & 2b_2 & 3c_2 \\ a_3 & 2b_3 & 3c_3 \end{bmatrix}$$

It is therefore apparent that pre-multiplication and post-multiplication by a diagonal matrix has significance for the rows and the columns respectively of the operand.

Transposition

If we examine the two matrices **a** and **b** below it is seen that the columns of **b** and the rows of **a** are identical

$$\mathbf{a} = \begin{bmatrix} a & p & s \\ b & q & t \\ c & r & u \end{bmatrix} \qquad \mathbf{b} = \begin{bmatrix} a & b & c \\ p & q & r \\ s & t & u \end{bmatrix}$$

The matrix **b** is said to be the transpose of **a** and we denote the transpose of **a** by **a**′. It follows that

$$\mathbf{b} = \mathbf{a}'$$
$$\mathbf{b}' = (\mathbf{a}')' = \mathbf{a}$$

Some examples involving transposition are given below

$$\begin{bmatrix} 1 & 2 & 3 \\ 0 & 2 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 \\ 2 & 2 \\ 3 & 1 \end{bmatrix} = \begin{bmatrix} 14 & 7 \\ 7 & 5 \end{bmatrix}$$

$$\begin{bmatrix} 1 & 0 \\ 2 & 2 \\ 3 & 1 \end{bmatrix} \begin{bmatrix} 1 & 2 & 3 \\ 0 & 2 & 1 \end{bmatrix} = \begin{bmatrix} 1 & 2 & 3 \\ 2 & 8 & 8 \\ 3 & 8 & 10 \end{bmatrix}$$

When a matrix is multiplied by its transpose, the product matrix is symmetrical in that it is unaltered by transposition.

$$\begin{bmatrix} 1 \\ 2 \\ 3 \\ 4 \end{bmatrix} [1 \quad 2 \quad 3 \quad 4] = \begin{bmatrix} 1 & 2 & 3 & 4 \\ 2 & 4 & 6 & 8 \\ 3 & 6 & 9 & 12 \\ 4 & 8 & 12 & 16 \end{bmatrix}$$

$$[1 \quad 2 \quad 3 \quad 4] \begin{bmatrix} 1 \\ 2 \\ 3 \\ 4 \end{bmatrix} = [1 + 4 + 9 + 16] = [30]$$

The product of a column matrix and its transpose is a square matrix whereas the product of a row matrix and its transpose is a simple number.

$$\begin{bmatrix} 1 & 0 & 2 \\ 3 & 1 & 0 \\ 4 & 2 & 1 \end{bmatrix} \begin{bmatrix} 6 \\ 2 \\ 5 \end{bmatrix} = \begin{bmatrix} 16 \\ 20 \\ 33 \end{bmatrix}$$

$$[6 \quad 2 \quad 5] \begin{bmatrix} 1 & 3 & 4 \\ 0 & 1 & 2 \\ 2 & 0 & 1 \end{bmatrix} = [16 \quad 20 \quad 33]$$

Thus the transpose of the product **ab**

$$(\mathbf{ab})' = \mathbf{b}'\mathbf{a}'$$

Special Matrices

A matrix **a** which is unaltered by transposition is said to be symmetric. Such a matrix is necessarily square. If the sign only of the element changes during transposition the matrix is said to be skew symmetric

Thus $\begin{bmatrix} 1 & 3 & 2 \\ 3 & -4 & -3 \\ 2 & -3 & 6 \end{bmatrix}$ is symmetric

Since $\mathbf{a}' = \mathbf{a}$

and $\begin{bmatrix} 0 & 4 & -3 \\ -4 & 0 & 2 \\ 3 & -2 & 0 \end{bmatrix}$ is skew symmetric

Since $\mathbf{a}' = -\mathbf{a}$

In the skew symmetric matrix the elements in the leading diagonal are necessarily zero to fulfil the condition

$$+ a_{ij} = - a_{ji}$$

The complex conjugate of a matrix **a** is denoted by $\bar{\mathbf{a}}$. The corresponding elements of a matrix and its complex conjugate are themselves complex conjugates.

Thus if

$$\mathbf{a} = \begin{bmatrix} 3 - j4 & 2 + j5 \\ 5 + j6 & 7 - j7 \\ 2 - j & 3 + j2 \end{bmatrix}$$

then

$$\bar{\mathbf{a}} = \begin{bmatrix} 3 + j4 & 2 - j5 \\ 5 - j6 & 7 + j7 \\ 2 + j & 3 - j2 \end{bmatrix}$$

The transposed conjugate of the matrix **a** is denoted by $\bar{\mathbf{a}}'$. Thus if

$$\mathbf{a} = \begin{bmatrix} 2 + j2 & 5 + j5 \\ 3 - j4 & 7 + j \end{bmatrix}$$

then

$$\bar{\mathbf{a}}' = \begin{bmatrix} 2 - j2 & 3 + j4 \\ 5 - j5 & 7 - j \end{bmatrix}$$

Note that the matrix

$$\begin{bmatrix} 6 & 1 + j3 & 2 - j2 \\ 1 - j3 & 4 & 3 - j2 \\ 2 + j2 & 3 + j2 & 0 \end{bmatrix}$$

is unaltered by transposition and the simultaneous taking of the complex conjugates of the elements. Thus $\bar{\mathbf{a}}' = \mathbf{a}$. Such a special matrix is called a Hermitian matrix.

Another special type of matrix is sometimes encountered where the condition $\mathbf{a}' = -\mathbf{a}$ is fulfilled.

$\mathbf{a} = \begin{bmatrix} j4 & -3+j2 \\ 3+j2 & j2 \end{bmatrix}$ is one of this type since $\mathbf{a}' = \begin{bmatrix} -j4 & 3-j2 \\ -3-j2 & -j2 \end{bmatrix} = -\mathbf{a}$

Such a matrix as $\mathbf{a}$ is said to be skew Hermitian.

Some Useful Matrix Operations

$$\begin{bmatrix} . & . & . & 1 \\ . & . & 1 & . \\ . & 1 & . & . \\ 1 & . & . & . \end{bmatrix} \begin{bmatrix} 1 & 3 & -4 & 2 \\ 5 & -6 & 1 & 0 \\ 2 & 0 & 3 & 4 \\ -1 & 5 & 7 & 1 \end{bmatrix} = \begin{bmatrix} -1 & 5 & 7 & 1 \\ 2 & 0 & 3 & 4 \\ 5 & -6 & 1 & 0 \\ 1 & 3 & -4 & 2 \end{bmatrix}$$

$$\begin{bmatrix} 1 & 3 & -4 & 2 \\ 5 & -6 & 1 & 0 \\ 2 & 0 & 3 & 4 \\ -1 & 5 & 7 & 1 \end{bmatrix} \begin{bmatrix} . & . & . & 1 \\ . & . & 1 & . \\ . & 1 & . & . \\ 1 & . & . & . \end{bmatrix} = \begin{bmatrix} 2 & -4 & 3 & 1 \\ 0 & 1 & -6 & 5 \\ 4 & 3 & 0 & 2 \\ 1 & 7 & 5 & -1 \end{bmatrix}$$

$$\begin{bmatrix} . & . & . & 1 \\ . & . & 1 & . \\ . & 1 & . & . \\ 1 & . & . & . \end{bmatrix} \begin{bmatrix} . & . & . & 1 \\ . & . & 1 & . \\ . & 1 & . & . \\ 1 & . & . & . \end{bmatrix} = \begin{bmatrix} 1 & . & . & . \\ . & 1 & . & . \\ . & . & 1 & . \\ . & . & . & 1 \end{bmatrix}$$

$$\begin{bmatrix} . & . & . & 1 \\ . & . & 1 & . \\ . & 1 & . & . \\ 1 & . & . & . \end{bmatrix} \begin{bmatrix} 1 & 3 & -4 & 2 \\ 5 & -6 & 1 & 0 \\ 2 & 0 & 3 & 4 \\ -1 & 5 & 7 & 1 \end{bmatrix} \begin{bmatrix} . & . & . & 1 \\ . & . & 1 & . \\ . & 1 & . & . \\ 1 & . & . & . \end{bmatrix} = \begin{bmatrix} 1 & 7 & 5 & -1 \\ 4 & 3 & 0 & 2 \\ 0 & 1 & -6 & 5 \\ 2 & -4 & 3 & 1 \end{bmatrix}$$

The square matrix $\mathbf{J}$ in which all the secondary diagonal elements are 1 and in which all the other elements are zero, is seen above to have significance in that it can reverse the order of the rows when used as a pre-multiplier and the order of the columns when used as a post-multiplier.

Another useful operator is the square matrix $\mathbf{U}$, in which all the elements are zero except those on the diagonal immediately above the leading diagonal; these elements are all unity.

Thus $\mathbf{U} = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{bmatrix}$ for $n = 4$.

The following operations involving $\mathbf{U}$ have a significance which will be apparent to the reader.

$$\begin{bmatrix} . & 1 & . & . \\ . & . & 1 & . \\ . & . & . & 1 \\ . & . & . & . \end{bmatrix} \begin{bmatrix} . & 1 & . & . \\ . & . & 1 & . \\ . & . & . & 1 \\ . & . & . & . \end{bmatrix} = \begin{bmatrix} . & . & 1 & . \\ . & . & . & 1 \\ . & . & . & . \\ . & . & . & . \end{bmatrix}$$

$$\begin{bmatrix} . & 1 & . & . \\ . & . & 1 & . \\ . & . & . & 1 \\ . & . & . & . \end{bmatrix} \begin{bmatrix} . & . & 1 & . \\ . & . & . & 1 \\ . & . & . & . \\ . & . & . & . \end{bmatrix} = \begin{bmatrix} . & . & . & 1 \\ . & . & . & . \\ . & . & . & . \\ . & . & . & . \end{bmatrix}$$

In general $\mathbf{U}^n = 0$ where n is the order of the matrix $\mathbf{U}$.

$$\begin{bmatrix} . & 1 & . \\ . & . & 1 \\ . & . & . \end{bmatrix} \begin{bmatrix} -3 & -4 & 2 \\ 6 & 1 & -2 \\ 2 & 5 & 1 \end{bmatrix} = \begin{bmatrix} 6 & 1 & -2 \\ 2 & 5 & 1 \\ . & . & . \end{bmatrix}$$

$$\begin{bmatrix} . & 1 & . \\ . & . & 1 \\ . & . & . \end{bmatrix} \begin{bmatrix} 6 & 1 & -2 \\ 2 & 5 & 1 \\ . & . & . \end{bmatrix} = \begin{bmatrix} 2 & 5 & 1 \\ . & . & . \\ . & . & . \end{bmatrix}$$

The reader is advised to work out further examples of this type and especially to post-multiply a chosen matrix by $\mathbf{U}$ since this operation is not included above.

If a more general approach to the subject is desired the writer recommends the serious reader to consult the book " Determinants and Matrices " by A. C. Aitken.

(To be concluded)

NEW BOOKS

The Services Textbook of Radio. Vol. III—Electronics. By J. Thomson. Pp. 259; figs. H.M. Stationery Office, York House, Kingsway, W.C.2. Price 12s 6d.

The new Services Textbook of Radio, of which this is the first volume to appear, is a series of seven volumes which covers fundamental physics of radio, telecommunications, radar and direction finding. The appeal is broad: to three classes of reader, beginners, technicians and more advanced readers as well. This is accomplished by marking the more difficult parts of the text and relegating mathematical proofs to appendices, which immediately follow the chapters to which they refer.

The volume on electronics commences with the physics of thermionic emission and the basic gridded valve types. It then considers valves as non-linear circuit elements. High frequency valves are covered in two chapters and the others deal with noise, gas tubes, semi-conductors, electron optics, c.r. tubes and photo-electric devices.

The author has been very successful in giving an account of valve operation which should be entirely satisfactory for the valve user. Clearly, the detail is quite insufficient for those interested in valve design. A major criticism of the book is that there are no references and no bibliography, so that those who study it outside organised classes cannot obtain any guidance on further reading. Finally, it should be said that the book is well printed, strongly bound and very cheap.—A.H.W.B.

Engineering and Fluid Mechanics. By Charles Jaeger. Pp. 529; figs. Blackie & Son, Ltd., 17, Stanhope Street, Glasgow, C.4. Price 60s.

This book is a translation by P. O. Wolf, lecturer in hydraulics at the Imperial College, of a book first published in German in 1949 and in French in 1954. The author has revised the original text and made some additions, and has approved the translation.

The subject of hydraulics is examined with particular reference to hydro-electric developments but the theory is of course relevant to any works where the movement and control of water is involved. The first of four parts deals with the more elementary basis of hydraulics and the second examines the basic hydrodynamic equations and goes on to consider varied conditions of flow in open channels. The third part, amounting to almost half the text, deals with conditions of unsteady flow resulting in mass oscillations and water hammer: problems in computing surge arrangements are dealt with fully. The fourth part concerns ground-water flow.

Although of necessity largely theoretical in treatment, the text covers clearly a great many practical points of application in hydro-electric design. The index is good, the bibliography is excellent and is given page by page as required. The work fills a long-standing gap in technical literature and should be a great help and guide to many engineers in a frequently controversial field.—H.R.M.

The Classification and Coding of Accounts. By J. M. S. Risk, B.Com., Ph.D., F.C.W.A., C.A., A.C.I.S. Pp. 79. Published for the Institute of Cost and Works Accountants by Gee & Co. (Publishers), Ltd., 27-28, Basinghall Street, London, E.C.2. Price 7s 6d.

A.C. Switchgear. Vol. 1—A Survey of Requirements. By J. R. Mortlock, B.Sc.(Eng.), Ph.D., M.I.E.E., M.A.I.E.E. Pp. 387; figs. Chapman & Hall, 37, Essex Street, London, W.C.2. Price 42s.

Ethoxylene Resin Moulding

Properties and Electrical Applications

IMMEDIATELY after the last war, ethoxylene, or epoxy resins, became readily available to the electrical industry, and since then have rapidly assumed an important place in the list of materials used by designers of electrical machinery and apparatus. The basic resins themselves are marketed under trade names, e.g. "Araldite," but to them, during casting, can be added plasticisers and fillers, to produce various characteristics in the finished products. The function of the fillers is not only to give a particular characteristic to the final mixture, but also to provide bulk, thus reducing the cost of the otherwise expensive material.

The main features of the ethoxylene resins, which are displayed in "Ethox,"* a material produced to a particular formula for the industry and exploiting their properties, are shown in the table.

The mouldings compare favourably with porcelain in their non-tracking properties, and are said to be far superior to s.r.b.p., or phenolic mouldings in this respect. Tests carried out at 11 kV with power arcs, under oil, indicate that this property will be very useful in the construction of arc control devices, tap change switch bases, etc. Tests for a period of one year on the basic resin, when mouldings were immersed in water at 40 deg C, indicate there is less than 1 per cent increase in weight, without any reduction in the strength of the material. This figure shows much lower water absorption than p.v.c. and about the same as the phenolic resins.

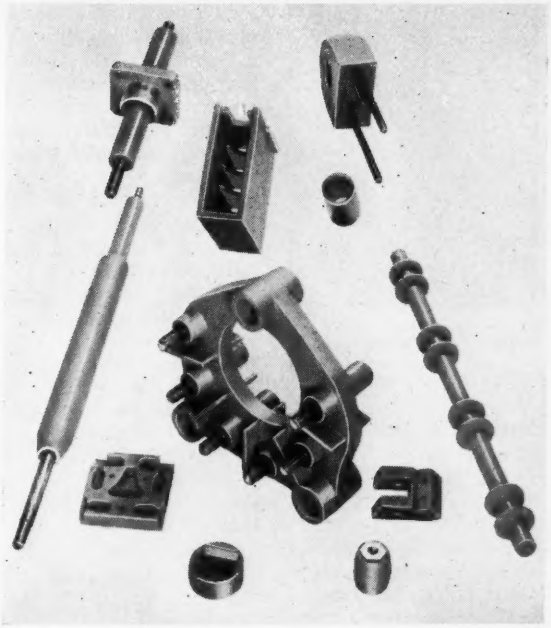
Ethoxylene is resistant to 32 per cent concentration of accumulator acid at 40 deg C, and this makes it a possible material for the construction of transparent battery cases. It is fully resistant to mineral oil at 50 deg C, and is fully resistant to the salt spray bath test at 20 deg C for at least 12 months. Weathering in an industrial atmosphere has been carried out for over three years without any reduction in the flexural strength of the material.

"Ethox," the filled resin mixture, is extremely tough to machine. It is preferable for holes and slots to be cast in the products, as only materials such as tungsten carbide have any reasonable life when machining them. The adhesion of the resins to copper, brass, aluminium, etc., is good, even allowing for the shrinkage which takes place in casting, and this facilitates the manufacture of oil tight bushings up to 15 kV. Submerged flange edges also improve the ionisation levels.

Ethoxylene resins are not able to operate at the same elevated temperatures as those materials recently developed from silicon, but certain of them can nevertheless function as an electrical insulating material with reasonable mechanical strength, up to 120 deg C. Above this figure the mechanical strength falls off, but this still leaves a big field of uses, where other plastic materials are unsuitable.

Unless there are special requirements, such as improved mechanical performance, ethoxylene mouldings cannot, in general, compete with porcelain, and prices may vary from 20 per cent to 100 per cent more than the porcelain products. For small quantities ethoxylene mouldings can be considered for applications where phenolic mouldings could be used, but where the latter are uneconomical owing to high tool costs.

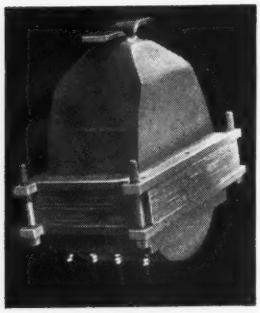
The cost of ethoxylene moulding tools is relatively low, as mild steel tools are perfectly satisfactory. This is made possible because the casting process is a gravity one, followed by the moderate curing temperature of 160 deg C. Thus special heat resisting steels are unnecessary. Experience has shown that the tool costs for phenolic mouldings may be two to three times those for ethoxylene mouldings, but the product cost on the other hand, is just



Group of moulded products for service in equipment ranging from 660 V to 11 kV and incorporated in switchgear, power transformers, capacitors, large motors, etc.

* "Ethox" is the registered trade name of ethoxylene products made by J. R. Ferguson (Electrical Engineers), Ltd.

Mechanical Properties	
Tensile strength	9,500 lb/sq in measured on ⅜in dia. specimen at 20 deg C.
Compressive strength	20,000 lb/sq in measured on ⅜in dia. specimen at 20 deg C.
Young's modulus of elasticity	1×10^6 lb/sq in
Specific gravity	1·7
Izod impact strength	0·25 ft/lb on ½in notched specimen to B.S. 771 : 1954.
Water absorption	24 hr at 20 deg C — 0·04 per cent.
Thermal Properties	
Coefficient of thermal expansion	35×10^{-6} per deg C.
Coefficient of thermal conductivity	20×10^{-4} cal/sq cm/deg C/cm.
Marten's point (heat resistance)	115 deg C.
Loss in weight on heat ageing	Loss in weight after ageing specimen at 100 deg C for 200 hr was less than 0·005 per cent.
Electrical Properties	
Dielectric strength	400/450 V/mil at 50 c/s on ¼in thick specimen under oil.
Dielectric constant	4·05 at 5 kV.
Tracking resistance	Longer than 15 min is taken to track using E.R.A. Test at 270 V a.c. r.m.s.
Surface resistivity	10^{13} ohms/cm.



Current transformer moulded in "Ethox" and suitable for an 11 kV 250 MVA system

the opposite. On small quantities of, say, 250, where a "moulding" is desirable, it is possible, therefore, that an epoxy resin moulding may be more economical, as well as being a better non-tracking material.

It is in the field of bushings, where s.r.b.p. has been so popular for many years, that the epoxy resins will have their greatest appeal to the designer. Not only are the non-tracking properties, the mechanical strength and durability acceptable, but the costs of bushings in these resins, up to 15 kV, can be from 15 per cent to 25 per cent less than the s.r.b.p. equivalent. Furthermore, sharp edges in vulnerable situations like spout connections, can be immersed in the moulding and corona levels improved.

For certain applications cost advantages can also be shown in comparison with costs for products in laminated wood, fabric filled Bakelite, etc.

The properties of "Ethox," using the basic "Araldite" epoxy resin, fulfil all the requirements for current transformer insulating material, namely: adequate mechanical strength; ability to withstand thermal shock; resistance to tracking; high dielectric strength; low loss angle; low moisture absorption; small shrinkage in order to minimise mechanical strains in the core materials; ability to maintain properties in tropical or polluted atmospheres.

A three-phase set of current transformers, mounted on 7in centres, recently successfully withstood the following short currents on test at the K.E.M.A. (Netherlands) plant.

	Peak kA	*R.M.S. kA*	*Peak A Turns*	*R.M.S. A Turns*	*Duration of Test*
Red phase	21·8	14·4	327,000	216,000	1·15 sec
Yellow phase	31·1	14·3	466,000	214,000	
Blue phase	33·4	13·9	500,000	208,000	

Impulse tests have been carried out and withstand levels of 80 kV positive and 80 kV negative were attained with a 1/50 microsecond wave. Higher levels can be realised by changing the configuration of the moulding. Ionisation levels are high since the edges of the earthed portions of the transformers are buried in the moulding material, which is itself free from voids, and the dry flashover level is at least 50 kV.

These moulded current transformers are robust and are eminently suitable for use in tropical, or polluted atmospheres, since the moulding material is non-tracking, and has the low water absorption characteristics of the ethoxylene resins.

Competition from Eastern Europe

The New Economic Offensive

By R. E. KAAN, Dipl. Ing.

SINCE Russia's assumption of a "new look," signs of the coming eastern offensive by herself and her satellites have been obvious to visitors to fairs abroad. Exhibition halls, impressive not so much by their contents as by their size and layout, have marked the beginning of the campaign. This propaganda onslaught has been vigorously supported by the distribution of multi-lingual brochures, announcing industrial achievements during the past year and describing new products. Full-page advertisements of Hungarian and Czechoslovakian electrical equipment in Far Eastern technical periodicals serve the same purpose.

Hungary and Czechoslovakia, with their highly developed industries, have been chosen to act as spearheads of the eastern economic offensive, and have already in many cases successfully penetrated under-developed countries with deliveries of electrical plant and equipment. As in the case of other satellite countries, both were unable after the war to resume their former trade links with the West, leaving Russia and the other Iron Curtain countries to absorb the bulk of their exports.

Czechoslovakian and Hungarian exports have recently not only changed their destination but also their nature—from agricultural products and clothing to mechanical and electrical equipment. Supported by substantial supplies of raw materials and semi-finished articles from Russia, both countries have successfully restored their industries. Former private electrical firms were nationalised, and special export organisations established, dealing with a large variety of products, including power plant. These State-owned export combines not only exist in the Iron Curtain countries themselves, but also in East Germany.

Although the main trade of these countries is conducted on a barter basis between themselves, there can be no doubt that no efforts will be spared to increase their electrical exports to the outside world. The recent Russian Five-Year Plan, incorporating the other Eastern Bloc countries, includes measures relating not only to the common choice of building sites and co-ordination of production methods, but also to standardisation of electrical goods and allocation of export markets. Closest co-operation is aimed at with the Near and Middle East, South Africa and South-East Asia, by undercutting established price levels, extension of credit terms, and quoting short delivery periods. The initial negotiations are conducted either by technical missions, or in many cases on a diplomatic or political basis, a recent example being the wooing of Egypt in connection with the High Aswan Dam project, both financially and technically.

Though the United Kingdom electrical manufacturer may have potential outlets for his products in Eastern Europe he will undoubtedly in future have to count with another extremely formidable competitor in world markets.

Factory Equipment Exhibition

THE theme of the fifth Factory Equipment Exhibition to be held at Earls Court, London, from 29th April to 4th May, 1957, will be "Greater efficiency in industry." Exhibits will cover every type of modern factory equipment for both large and small works. Details regarding space, etc., may be obtained from the Organiser, Factory Equipment Exhibitions, Ltd., 4, Snow Hill, London, E.C.1.

VIEWS on the NEWS

By REFLECTOR

ELECTRICITY Boards are still experiencing great difficulty in justifying to consumers the floor-area basis of charging for electricity. A correspondent calling himself "Pensioner" complained of this system in a letter to the *Kent Messenger* and as a result received a suggestion from the South Eastern Electricity Board that it would be to his advantage to go over to the alternative flat-rate charge. In response to this he again writes to the paper saying:—

> "I did not ask for charity or special treatment. I asked for information as to who authorised the South Eastern Electricity Board to measure up the cubic capacity of the house I live in and to level unlawful charges on my rent-controlled house."

In the same issue Sir Alfred Bossom, M.P. for Maidstone, says that in certain cases, such as that of "Pensioner," electricity is charged for which is not even used "and in fact I have had cases brought to my attention where charges were made for rooms not even wired for electricity."

I am afraid that until the really all-electric age arrives such apparent inequities must continue to arise. One day perhaps it will be possible to apply a universal flat rate.

* * *

Still on the subject of tariffs I notice that a member of the Council of the Exeter and District Chamber of Commerce recently asked at a meeting why the electricity charges of the South Western Electricity Board were higher than those of the Southern Board. As reported by the *Western Morning News*, he said that he had noticed accounts from the South Western Board and the Southern Board which were within 500 units of one another, yet the South Western Board charge was more than double that of the Southern Board.

This certainly seems to be a bit steep but there may be some virtue in that "within 500 units of one another." One would expect a bill for, say, 700 kWh to be considerably greater than one for 200 kWh. It would have been better to have quoted actual quantities.

* * *

During an "At Home" day at Dunston power station an opportunity was given to visitors to inspect one of the C.E.A. North Eastern Division's ash-barges. The vessel evidently possesses interest, for the *Nor' Easter* (the local Board and Division magazine) says:—"There is more in an ash-barge than meets the eye on a windy day."

* * *

The village of Castlemorton in Worcestershire cannot obtain electricity until a controversy is settled. The County Planning Committee has agreed to overhead lines but has stipulated that the cross-arms of the poles in the village shall be painted green "to harmonise with the countryside," which the Midlands Electricity Board is loth to do. When this question was discussed by the Area Consultative Council a member said he hoped that if a compromise was reached the provision of a supply would be speeded up, adding "We want this silly little matter smoothed over as quickly as possible." I quite agree with the latter remark but am left wondering what the result of a compromise would be.

* * *

According to the *Stretford and Urmston News-Telegraph*

> "A contract valued at £1¾ million has been awarded to Metropolitan-Gorge Electrical Co., Ltd., for the supply of generators required for the first stage of the Zambesi hydro-electric scheme at Fariba Vickers, Rhodesia."

Later on we are informed that the generators are "each rated at 100 MW 0·9 power factor 18 kV three-chase 50 cycles."

* * *

It has always seemed to me that street lighting is the "Cinderella" of the public services and this impression was not dispelled by the somewhat brusque answer which Mr. Hugh Molson, Parliamentary Secretary to the Ministry of Transport, gave recently to a question by Lieut.-Col. Lipton, who asked what steps the Minister was taking to obtain uniform lighting on main roads. Mr. Molson said the Government did not at present propose to initiate any legislation on this subject, and that they were "not disposed to spend on lighting more of any money which is available." Apart from the fact that the question concerned lack of uniformity, which is a constant source of complaint and increases the risk of accidents, a large number of lighting improvement schemes do, in fact, save money by making use of more economic sources of light.

* * *

Sixty years ago the *Electrical Review* commented upon a high-speed monorail system invented by a Mr. F. B. Behr. One criticism in the issue dated 7th August, 1896, related to what might happen to passengers when the cars were rounding sharp curves. The *Review* said:—

> "From Mr. Behr's own showing, the centrifugal force of a particle travelling round a 25 chain radius curve is, at 150 miles per hour, 1·4 times the weight of the particle. Now all this may be provided for in the vehicle, but not a word is said about passengers. Going round such a curve, an average passenger of 150 lb weight would be forced to the outside of the curve with a pressure of 210 lb. It would be all right for the passengers on the outer side but the inside, or, as we will term them, the concave passengers would simply be flung across the car upon their *vis-à-vis*, and this, however pleasing under certain circumstances with curves of fairly flat radius, would be extremely dangerous with the sharper curves. Now Mr. Behr absolutely ignores the passengers. Super-elevation of the track, or the Behr equivalent of super-elevation, will not help the passengers much. Full super-elevation would simply make a passenger sit tight to the tune of his own weight plus 1·4 times his weight. The present writer would weigh 360 lb for the nonce. Our worthy editor in such a case would weigh about 520 lb. These are serious figures. They show what great overturning efforts are made upon the structure."

PERSONAL AND SOCIAL

News of Men and Women of the Industry

Mr. H. J. Randall, C.B.E., F.C.I.S., Companion I.E.E., formerly chairman of the London Electricity Board, has been appointed a director of Enfield Cables, Ltd., and will assume the chairmanship of the company on 1st October next. He will succeed **Sir Philip Warter** who, at his own request and because of increasing business commitments, will relinquish the chairmanship on that date but remain a director of the company.

In our last issue we briefly reported that **Mr. E. W. Bussey,** C.B.E., was relinquishing his appointment as chairman of the Employers' Side of the Joint Negotiating Committees covering the electricity supply industry, on 31st December next.

Mr. E. W. Bussey

Mr. Bussey has throughout his life been associated with the electrical industry. He began his career in 1909 with the West Ham electricity undertaking, and later served with the L.C.C. Tramways Department and the London Passenger Transport Board. He was general president of the Electrical Trades Union from 1931 to 1941, when he became general secretary of the Union, a post he held until 1947 when he was appointed a full-time member of the British Electricity Authority, with special duties in the field of labour relations and welfare. During the years 1941 to 1947 Mr. Bussey served as a member of the General Council of the T.U.C. He was a member of the Ministry of Production's Industrial Panel from 1942 to 1945, and was made a C.B.E. in 1946.

When Mr. Bussey retired from his membership of the Authority in 1952 he was appointed chairman of the Employers' Side of the Joint Negotiating Committees, and in that capacity took charge of labour conciliation.

The Minister of Fuel and Power has reappointed **Alderman A. E. Bennett,** J.P., of Stoke-on-Trent, and **Mr. S. F. Burman,** C.B.E., of Birmingham, as part-time members of the Midlands Electricity Board.

A reorganisation of the executive staff of Charles Colston, Ltd., and its subsidiary companies is announced. **Mr. Michael Colston,** a director, has been appointed acting director of research and development. The new bay at the Aycliffe factory of Tallent (Aycliffe), Ltd., has now been taken over by Charles Colston, Ltd., for the forthcoming manufacture of labour-saving household appliances with **Mr. A. R. Northover,** a director of Tallent (Aycliffe), Ltd., as general manager of the factory. **Mr. C. T. Howard** retains his present responsibilities as director and general manager of Tallent (Aycliffe), Ltd. **Mr. H. C. Addis,** a director of Smith-Richards, Ltd., has in addition been appointed general manager of that company and **Mr. A. Lukins** has been appointed acting secretary.

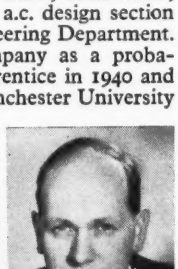
The Simplex Electric Co., Ltd., announces that consequent upon the resignation of its export manager, **Mr. L. W. Baldwin,** who is leaving to join the company's Creda Division agents in the Rhodesias, it has appointed **Mr. A. W. Strickland** as export manager, Simplex Division, at Oldbury, and **Mr. D. G. Woodhall** as export manager, Creda Division, at Blythe Bridge.

Mr. A. S. Johnson, chief electrician at Wheatley Hill Colliery, has been presented by his colleagues with an oak hall table on his retirement after thirty-six years' service.

The article in this issue on "High Speed Induction Motors" is by two members of the staff of the Metropolitan-Vickers Electrical Co., Ltd. **Mr. W. Hill,** Assoc.M.C.T., A.M.I.E.E., is in charge of development work in the Motor Engineering Department. He received his technical education at the Manchester College of Technology and joined the company as a school apprentice in 1936. After war service with the Royal Engineers, during which he was mentioned in despatches, he returned to Metropolitan-Vickers to design induction motors. He maintains that the theory of relativity and the tensor calculus are indispensable for an understanding of rotating electrical machinery and their future development.

Mr. J. K. Vose, B.Sc., A.M.I.E.E., is a member of the a.c. design section of the Motor Engineering Department. He joined the company as a probationary college apprentice in 1940 and graduated from Manchester University in 1943. After war service with the Royal Naval Volunteer Reserve he returned to the company to complete his apprenticeship and joined the Motor Engineering Department in 1948.

Mr. W. Hill



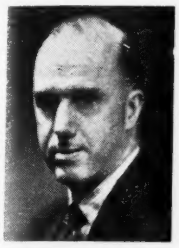
Mr. J. K. Vose

The 10th examination under the diploma scheme of the **Association of Supervising Electrical Engineers** was held at London and Manchester Centres during May last, and the following candidates were successful:—A.S.E.E. Diploma in (a) Electrical Installation Practice: Messrs. F. Crossley (Radcliffe, nr. Manchester); R. E. Elmes (Bayswater, London); J. S. Eynon (Burghfield, nr. Reading); and N. Whittle (Preston). In (b) Electrical Maintenance: Messrs. J. Ainsworth (Blackburn) and H. Twemlow (Nottingham). A.S.E.E. Technicians' Certificate: (a) Specialist Section—Installation Work: Messrs. N. English (Paignton, Devon) and E. J. Ware (Romford, Essex). (b) Specialist Section—Maintenance Work: Messrs. N. English (Paignton, Devon); I. McL. Ireland (Upper Largo, Fife); J. S. Low (Coningsby, Lincs); A. J. Rice (Peckham, London); and G. A. Tayler (Banbury, Oxford). (c) Specialist Section—Design and Layout: Messrs. E. F. Cooper (Twickenham, Middx) and C. Pooley (Wednesfield, Staffs).

Mr. P. Mathews, B.A., of the Transformer Engineering Department of the British Thomson-Houston Co., Ltd., has retired after thirty years' service with the company. Mr. Mathews joined the B.T.H. Willesden drawing office in 1921, but later left to go to the General Electric Co., U.S.A., and spent periods at Philadelphia and Schenectady. He returned to the B.T.H. Co. at Willesden in 1927, and a year later transferred to the Transformer Engineering Department at Rugby where he was engaged on the design of current and voltage transformers. He did a great deal of work on protective schemes, and is author of a book on "Protective Current Transformers and Circuits" and joint author of an I.E.E. paper on "Capacitor Voltage Transformers."

Mr. P. Mathews

The **Metropolitan-Vickers Electrical Co., Ltd.,** is revising its "Register of Ex-Apprentices and Ex-Trainees." The last edition, containing 10,000 short biographies, was published in 1950, and forms asking for present particulars have been sent to all those


Mr. W. S. Steel

Mr. E. V. Bowers

Mr. E. G. Crossling

Mr. G. S. C. Lucas

Mr. V. M. Roberts

whose addresses are known to the company. Any ex-apprentice or ex-trainee who has not received a form (or has not yet replied to one) is invited to write to Mr. R. F. Marshall, manager, Education Department, Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester, 17.

Lord Burghley, K.C.M.G., Hon. LL.D., chairman of A. C. Cossor, Ltd., has succeeded his father, who died on 6th August, as the Marquess of Exeter.

Mr. Edgar Butterworth, A.S.A.A., deputy secretary of the North West, Merseyside and North Wales Division, Central Electricity Authority, has been appointed director of labour and welfare to the Division. Mr. Butterworth was educated at the Moravian Church School at Fulbeck, near Leeds. He served articles with a firm of chartered and incorporated accountants at Ashton - under - Lyne. After a few years in a professional accountant's office he joined the Stalybridge, Hyde, Mossley and Dukinfield Transport and Electricity Board with which he served in various senior administrative posts, becoming clerk and treasurer of the Board in 1948, in which year he was appointed secretary of the Merseyside and North Wales Division. He became deputy secretary of the enlarged Division on the amalgamation with the North Western Division.

Mr. E. Butterworth

Keith Blackman, Ltd., have appointed the following executives to serve as directors:—**Mr. C. J. Atkins** (sales director), **Mr. F. W. Goodge** (contracts director) and **Mr. S. Hudson** (director and London works manager). **Mr. A. H. Woodley** has been appointed sales manager.

Mr. G. M. Davies has been appointed information officer to the Merseyside and North Wales Electricity Board. He has been the Port of Bristol Authority's publicity and public relations officer for the past five years and is a well-known journalist and broadcaster. Mr. Davies is a member of the Institute of Public Relations and president of the Bristol and West of England Publicity Club.

Following the withdrawal of the Rank Group interest from Sound Equipment, Ltd., the company has become a wholly owned subsidiary of the British Thomson-Houston Co., Ltd., and it is the intention to change the name of the company to B.T.H. Sound Equipment, Ltd. Messrs. J. Arthur Rank, J. H. Davis, A. S. Kettle, E. S. Little, J. Metcalfe and W. W. Vinsen have retired from the board to which the following new appointments have been made:—**Mr. W. S. Steel** (chairman), **Mr. E. V. Bowers,** M.B.E. (managing director), **Mr. E. G. Crossling, Mr. G. S. C. Lucas,** O.B.E., and **Mr. V. M. Roberts,** O.B.E. The company will continue to supply and service cinema equipment and will also broaden the scope of its activities in this field.

Mr. Orlando Oldham has been appointed to the board of Oldham & Son Africa, Ltd., one of the overseas companies of Oldham & Son, Ltd. He joined the board of the parent company last year.

Mr. R. P. Warburton and **Mr. David A. Syme,** the Australian and New Zealand representatives respectively of the Martindale Electric Co., Ltd., London, are on a visit to this country. Mr. Warburton is a director of the New South Wales electrical firm of Warburton, Franki, Ltd., Sydney, while Mr. Syme is managing director of David A. Syme, Ltd., Wellington, N.Z.

Mr. F. C. Woodward, of Kin Electric, Ltd., Nottingham, has been elected national president of the Radio and Television Retailers' Association.

W. T. Henley's Telegraph Works Co., Ltd., have appointed **Mr. W. L. Willey** to be manager of the Birmingham branch as from 1st October in succession to **Mr. F. C. Horsford,** who will be retiring for health reasons. Mr. Willey joined the Hull branch in 1931 and was appointed manager of the branch in 1946.

Mr. R. K. Palmer will succeed Mr. Willey as Hull branch manager. He joined the company in 1936, was transferred from head office to Hull in 1946, and has been the representative assisting Mr. Willey. **Mr. S. W. Featherstone,** chief clerk of the branch, becomes branch representative.

Mr. W. J. Combellack is appointed manager of the Leicester branch. He joined Henley's in 1922 and for a number of years was a representative at the Nottingham branch before being transferred at the beginning of this year to take charge of the Leicester store.

Mr. J. S. George becomes Cardiff branch representative to assist the manager, Mr. J. M. Faulkes. Mr. George was chief clerk at the branch.

Mr. R. V. Maller is appointed Colchester branch representative to assist the manager, Mr. S. L. Crafford. He was transferred from the Rubber Cable Sales Division at head office.

Mr. F. E. Jones, M.B.E., B.Sc., Ph.D., A.M.I.E.E., and **Mr. J. D. Stephenson,** B.Sc., M.Sc., Ph.D., M.I.E.E., have been appointed to the board of Mullard, Ltd.

Following an appointment at Kings College, London, where he graduated, Dr. Jones was on the staff of the Telecommunications Research Establishment from 1940 to 1952. He was awarded the M.B.E. in 1945 for his work on "Oboe," the wartime blind bombing system, and in 1952 was made a deputy chief scientific officer. Following promotion to chief scientific officer in 1953, he was appointed deputy director of the Royal Aircraft Establishment, Farnborough. Whilst in Government service Dr. Jones' main contributions were in the field of electronics and solid state physics, and he was awarded the Duddell Premium of the Institution of Electrical Engineers in 1949.

Dr. Stephenson received his scientific training at the University of Durham, where he took degrees in physics, applied science and electrical engineering. After four years' research work at the University he joined the Mullard organisation in 1933. He has worked on all aspects of manufacture, including production, development and materials research, and since 1946 has been in charge of valve manufacture for the Mullard group of

Dr. F. E. Jones

Dr. J. D. Stephenson

companies. Dr. Stephenson is also a director of the Mullard Radio Valve Co., Ltd., and Mullard Blackburn Works, Ltd.

Dr. D. G. O. Morris, D.Sc., A.M.I.E.E., senior lecturer at the University College of North Wales, Bangor, has been appointed to the University Readership in Electrical Engineering tenable at the Imperial College of Science and Technology.

OBITUARY

Mr. A. J. Sands.—The death occurred on 31st July, at the age of fifty-five, after a short illness, of Mr. Alexander John Sands, A.M.I.Mech.E., manager of the Leyton factory of the London Electric Wire Co. & Smiths, Ltd. He joined the company in July, 1923.

Mr. E. V. C. Habgood, purchasing officer in the Essex Sub-Area of the Eastern Electricity Board, died on 25th July at the age of sixty-four. Mr. Habgood commenced his career in the electricity supply industry nearly fifty years ago and served before vesting day with the Southend-on-Sea Corporation Electricity Department.

Mr. Cyril A. Baker, A.M.I.E.E., died suddenly following an operation on 3rd August. He had been manager of the Electric Control Gear Works of William Geipel, Ltd., since 1946 and had recently been appointed a service director.

WILLS

Dr. Oscar Faber, C.B.E., D.Sc., F.C.G.I., M.I.C.E., M.I.Mech.E., M.I.E.E., consulting engineer, senior partner in Oscar Faber and Partners, who died on 7th May last, left £287,778 gross (£265,710 net)

Mr. W. M. Furniss, a former chairman and managing director of the Electric Construction Co., Ltd., who died on 9th April, left £23,291 gross (£22,373 net).

Mr. E. Brook, founder of Brook Motors, Ltd., who died on 16th April last, left £150,744 gross (£145,235 net). Probate has been granted to Martins Bank, Ltd.

Mr. E. P. Higgs, B.Sc., A.C.G.I., M.I.E.E., of the Chief Technical Officer's Department of the London Electricity Board; and with the Shanghai Power Co. for many years, died on 29th March, leaving estate in Great Britain valued at £16,619 gross (£16,536 net).

Mr. R. Illingworth, O.B.E., M.I.E.E., M.I.Mech.E., late constructional engineer, London Division, C.E.A., who died on 9th March last, left £14,929 gross (£13,940 net).

Mr. W. P. Barnell, of Northampton, for many years in business as an electrical contractor, who died on 8th May, intestate, left £5,033 gross (£1,427 net).

Mr. A. H. Law, formerly chief engineer of the English Electric group, who died on 24th March, left £9,944 gross (£9,827 net).

Mr. H. R. C. Van de Velde, former senior executive of the Marconi International Marine Communication Co., Ltd., who died in Johannesburg on 14th January, left £12,689 gross (£12,082 net).

Mr. J. B. Guild, A.M.I.E.E., second assistant engineer in the Thames Grid Control Centre of the Central Electricity Authority, who died on 28th January last, left £4,923 gross (£4,851 net).

Mr. F. G. Ferguson, for many years with the Metropolitan-Vickers Electrical Co., Ltd., who died on 12th March last, left £23,218 gross (£23,151 net).

Mr. E. R. Dymond, O.B.E., retired electrical engineer, who died on 16th January, left £30,984 gross (£30,791 net).

High Marnham Power Station

WORK has now started on the High Marnham power station of the Central Electricity Authority, East Midlands Division. Situated on the River Trent, the station will have an ultimate capacity of 1,000 MW in 200 MW turbo-alternators, thus representing both the largest single power station and sets yet installed in this country. The first set is due for commissioning in 1959. The boilers and turbines are designed for operation on the unit principle, and the plant will operate on a steam cycle with initial conditions of 2,350 lb/sq in and 1,050 deg F, and reheating to 1,000 deg F will be employed.

The tandem compound turbo-generators, arranged longitudinally in the turbine house, will have three h.p. and three l.p. feed heaters capable of producing a final feed temperature of 460 deg F, the third stage l.p. heater being arranged as a high level de-aerator. The feed water will be returned to the boilers by two-stage pumping, there being two 100 per cent booster and two 100 per cent main feed pumps, one pump providing automatic standby for the other. The generators will be hydrogen cooled at a pressure of 30 lb/sq in. There will be two gantry cranes in the turbine house, one designed to handle the heaviest lift of 168 tons, and the other of lighter duty to carry out general maintenance.

The boilers will have a drum level of 130ft above floor level, and are designed in two casings, one containing the superheat and the other the re-heat furnace. They will be pulverised-fuel fired, the coal being stored in overhead bunkers having a capacity of 2,270 tons per boiler. Each boiler will be equipped with six pulverising mills, five of which will maintain maximum continuous rating, and the fuel will be fed into the furnaces through 48 burners arranged for corner firing. Each boiler will be fitted with a mechanical grit arrestor and an electrostatic precipitator, and the flue gases from the five units will be discharged through two reinforced concrete chimneys at a height of 450ft.

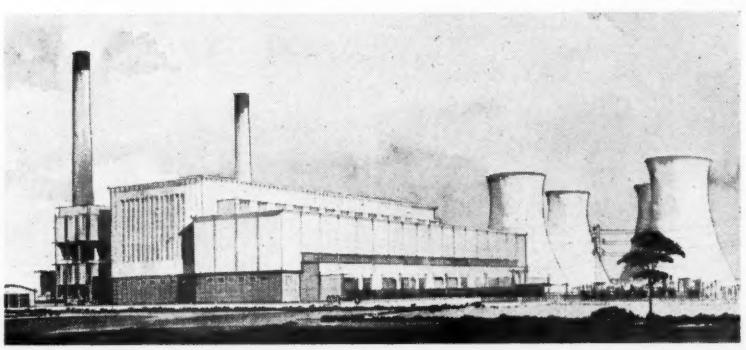
Cooling water for the condensers will be circulated through a closed system which will include five cooling towers and five circulating water pumps. Each tower will have a capacity of 5·4 million gallons per hour and will be connected into the system to be available on any machine. Make-up water will be drawn from the river at the rate of 33 million gallons per day and, less evaporation, will be returned to the river continuously.

The annual requirement for coal for the station will be 2·5 million tons; it will be delivered to site by rail in trains of thirty-four 24·5 ton wagons, at an average rate of 10,000 tons per day. The trains will be shunted into exchange sidings from which they will be drawn and to which they will be returned after emptying. These sidings will comprise 14 tracks, each 1,765ft long, which are designed to accommodate two trains. The wagons, which will be of the four door hopper type, will discharge through two ground hoppers to a system of conveyors capable of feeding the station bunkers or coal store at a rate of 1,000 tons per hour. The coal store, designed to cover seasonal fluctuations in the station demand, will have a total capacity of 250,000 tons. Mobile equipment will be used to stock out and reclaim the coal for use in the station bunkers. Ash and dust from the boilers will be collected at a central point and pumped through twin pipelines to the Besthorpe quarries about five miles away.

The generation voltage of 16·5 kV will be stepped up on site to 275 kV through 210 MVA transformers and fed through 275 kV outdoor switchgear into the supergrid. Auxiliary motors of more than 300 h.p. will operate at 6·6 kV and the remainder at 415 V.

The architecture of the station follows the Authority's latest practice in the adoption of lightweight cladding. The main building with coal conveyor structures will be sheeted in aluminium above a plinth course of pre-cast reinforced concrete facing slabs.

High Marnham power station will have an ultimate capacity of 1,000 MW and will employ 200 MW sets, with steam conditions of 2,350 lb/sq in and 1,050 deg F



Restrictive Trade Practices

Provisions of the New Act

By C. F. MAYSON, A.M.I.E.E.

THE Restrictive Trade Practices Act, 1956, which received the Royal Assent on 2nd August and, for the most part, comes into operation one month from that date, has two main purposes. The first is to provide for the registration of an extensive category of restrictive trading agreements, for their judicial examination by a special Court, and for the prohibition of those found to be contrary to the public interest. The second is to prohibit the collective enforcement of resale price conditions attaching to goods and, as a corollary, to enable individual manufacturers or suppliers to enforce such conditions, irrespective of contract, against traders who take the goods with notice of the conditions. The Act also contains certain consequential amendments of the Monopolies and Restrictive Practices Acts, 1948 and 1953, and there are some supplemental provisions.

Constitution of Court

Part I of the Act sets up the machinery for the registration and judicial investigation of agreements. A Registrar of Restrictive Trading Agreements is to be appointed, charged with the preparation and maintenance of a register of agreements and with taking proceedings before the Court in respect of such agreements. A Restrictive Practices Court is to be established, designated a superior court of record, which means that it ranks as a Division of the High Court, and its general administration is under the Lord Chancellor. It will consist of five judges, one of whom will act as President, and not more than ten other members, and for the hearing of any proceedings a presiding judge and at least two other members must sit. The number of judges and other members may, if found expedient, be increased by order of the Lord Chancellor approved by resolution of Parliament. The judges are, in England, to be three High Court judges nominated by the Lord Chancellor; in Scotland, one judge of the Court of Session nominated by the Lord President; and in Northern Ireland, one judge of the Supreme Court nominated by the Lord Chief Justice of Northern Ireland. Provision is made to increase the number of judges in England and Scotland by three and one respectively. The other members are to be appointed by the Sovereign on the recommendation of the Lord Chancellor, and they are to be persons appearing to him to be qualified by virtue of knowledge of or experience in industry, commerce or public affairs. They will receive such remuneration as is approved by the Treasury.

Agreements required to be registered are those between any two or more persons carrying on business within the United Kingdom in the production or supply of goods, or in the application to goods of any process of manufacture, being agreements under which certain specific restrictions are accepted. "Goods" is defined as including "ships and aircraft, substances and animals (including fish), and references to the production of goods include references to the getting of minerals and the taking of such animals." The specific restrictions are those in respect of prices, terms and conditions of sale, quantities or descriptions of goods, processes of manufacture and the quantities or descriptions of goods to which such processes are to be applied, sources of supply or persons to be supplied, and areas or places in or from which goods are to be supplied or acquired or processed. "Agreement" includes any agreement or arrangement, whether or not intended to be legally enforceable, and "restriction" includes any negative obligation, express or implied.

Where, under an agreement, privileges or benefits are conferred only upon those parties who comply with specific restrictions, and obligations are imposed upon those who do not comply, that agreement is treated as one under which the restrictions are accepted by the parties. Where there is an obligation to make payments calculated by reference to quantities of goods produced, supplied or processed, or to quantities of materials for production or processing, and such payments are calculated in respect of quantities exceeding an agreed amount, such an obligation is regarded as a restriction.

Agreements made by trade associations are regarded as agreements made between all their members, and restrictions contained therein are treated as being accepted by the members. A "trade association" is a body of persons, whether or not incorporated, formed for the furtherance of the trade interests of its members; but interconnected companies and individuals in partnership are, for this purpose, single persons. Specific recommendations made by trade associations to their members as to the action to be taken in regard to specific restrictions will cause the agreement for the constitution of the association to fall within the Act, notwithstanding any provision to the contrary contained in the agreement, and that agreement will therefore have to be registered (unless the recommendations refer exclusively to export).

Excepted Agreements

Certain restrictions are to be disregarded. Those concerning the acquisition and supply of materials and products which have been approved by the Iron and Steel Board and the Board of Trade for the steel industry, and which are included in agreements between iron and steel producers, whether with or without other parties, are not taken into account. Restrictions affecting labour, specifying compliance with British Standard Specifications, or relating exclusively to the goods themselves, are likewise outside the Act. There are a number of excepted agreements. These are:—

(1) Agreements expressly authorised by Act of Parliament.

(2) Agreements under schemes certified by the Board of Trade as relating to the rationalisation of industry.

(3) Agreements between two persons neither of whom is a trade association where specific restrictions are accepted only by the party supplying the goods, in respect of the supply of similar goods to others, or by the party acquiring the goods, in respect of the sale of other similar goods.

(4) Licences, assignments or agreements to licence or assign in connection with patents and registered designs, or applications for the same, where there are specific restrictions relating only to the inventions or designs

concerned, or to articles made by the use of those inventions or to which those designs are applied.

(5) Agreements between two persons, neither of whom is a trade association, for the exchange of information relating to processes of manufacture, whether patented or not, there being no specific restrictions save in respect of the goods with which those processes are concerned.

(6) Agreements for the use of certificated trade marks within the Board of Trade Regulations made under the Trade Marks Act, 1938.

(7) Agreements between registered proprietors and registered users of trade marks (other than certification trade marks), there being no specific restrictions save in respect of the goods bearing the mark or marks.

(8) Agreements in connection with goods for export.

Appointment of the date or dates when the provision as to registration is to come into force is delegated to the Board of Trade. The Board is given a wide choice as to classifying agreements, and may appoint different dates for the registration of agreements of different classes. Orders made in this respect are exercisable by statutory instrument and are subject to approval by resolution of Parliament. It was announced in Parliament by the President of the Board of Trade on the day the Act received the Royal Assent that the first Order had already been made. This is the Registration of Restrictive Trading Agreements Order, 1956,* which, if approved by Parliament, will come into force on 30th November.

The particulars required for registration are the names of all parties to the agreement and the whole of its terms, whether or not relating to specific restrictions. If the agreement is in writing, the original or a true copy must be submitted; if made orally, then the particulars must be set down in a memorandum in writing signed by the person furnishing the particulars. It is sufficient if one party only submits particulars for registration. An agreement which is determined before the expiry of the time allowed for registration under a Board of Trade Order need not be registered. The Registrar is given powers to make regulations as to the procedure to be followed in furnishing particulars, the detailed particulars required, and similar matters. Such regulations are subject to annulment by resolution of Parliament.

The Register is to be in two portions, one of which will contain the bulk of agreements and will be available for inspection by the public upon payment of a fee. The other, called the special section, will contain particulars the publication of which would, in the opinion of the Board, substantially damage the legitimate business interests of any person. Power is given to the Board to direct the Registrar to remove particulars of insignificant agreements from the Register, but particulars of such direction must as soon as possible thereafter be laid before Parliament. The High Court has power to rectify the Register upon application by any person aggrieved, and it may declare whether or not a particular agreement is registrable.

The Registrar is given wide powers to obtain information and, where he has given notice to any person to furnish particulars or further information, he may apply to the High Court for that person to be called before the Court and examined on oath. Where a body corporate is concerned, any director, manager, secretary or other officer may be ordered to attend and be examined. Failure without reasonable excuse to comply with a Registrar's notice, or the furnishing of false information, or the wilful suppression, alteration or destruction of any document called for by the Registrar, renders the offender liable to penalties. Whilst it is merely a summary offence to fail to comply with a notice (the maximum fine being £100), the other offences carry imprisonment up to two years as an alternative to a fine.

The Restrictive Practices Court has jurisdiction to determine whether restrictions in particular agreements are contrary to the public interest. It is, perhaps, significant that restrictions are to be deemed contrary to the public interest unless the Court is satisfied as to certain matters laid down in a detailed manner by the Act. Put shortly, if the Court is satisfied that a restriction is reasonably necessary to protect the public against injury in connection with the consumption, installation or use of goods, or to counteract measures by outside parties to prevent or restrict competition, or to enable the parties to the agreement to negotiate fair terms with a powerful outside interest, then it is not contrary to the public interest. Or it may be satisfied that the removal of a restriction would deny to the public as purchasers or users substantial advantages, whether by virtue of the restriction itself or of arrangements resulting therefrom. If removal of restrictions would have an adverse affect upon employment in a given area, or would affect export business, then they may be allowed. But in any of these cases the Court must be satisfied that the restriction is not unreasonable.

The Court may vary its own decisions. Appeal on a point of law lies to the Court of Appeal (in Scotland, to the Court of Session). No appeal lies on a question of fact.

Resale Prices

Under Part II, agreements for the collective enforcement of resale prices are prohibited. To withhold supplies of goods, or to supply them on less favourable terms, or to supply goods only to persons who undertake to withhold supplies of goods from persons who resell in breach of a condition of sale, is unlawful, as is the imposition of penalties or the conduct of domestic proceedings in that connection. It is similarly unlawful to withhold orders for the supply of goods or to discriminate in the handling of goods against the goods of other suppliers. These provisions do not apply to contracts for the sale of goods to which there are only two parties, but they do apply to trade associations. Compliance is enforceable by civil proceedings on behalf of the Crown and, because many trade associations are registered as trade unions, it is enacted that the provision of the Trade Disputes Act, 1906, which prohibits actions of tort against trade unions, shall not apply to such proceedings.

Individual enforcement of resale prices is, however, allowed. Where goods are supplied subject to a resale price condition, the supplier may enforce the condition by legal proceedings against any person, not a party to the original sale, who acquires the goods for the purpose of resale and has notice of the condition. The Court has power to grant an injunction restraining the offending party from reselling in breach of the condition. A condition as to discounts or part-exchange is a condition of resale. References to selling goods include references to hire-purchase agreements within the Hire-Purchase Act, 1938, and to contracts within the Hire-Purchase and Small Debt (Scotland) Act, 1932. This part of the Act does not come into force until 2nd November.

This is a long and rather complicated Act. Space does not permit adequate consideration of the provisions of Part III, which alters the character of the Monopolies Commission (as it is now rightly called). Nor has it been possible to deal with some of the more detailed provisions contained in Parts I and II. Part IV is purely supplemental, but it does contain a provision which restricts disclosure of information respecting trades and businesses obtained under the Act, and there are penalties for contravention.

* H.M. Stationery Office, price 3d (by post 5d).

INDUSTRIAL NEWS

Consumers' Control Units

Regulation 105 of the 13th edition of the I.E.E. Regulations for the Electrical Equipment of Buildings states:—"The consumer's main fuse(s) or circuit-breaker may be omitted provided (i) the supply undertaking so agrees and (ii) sub-circuit fuse(s) or circuit-breaker(s) providing any necessary further electrical protection are within reach from the main switch."

The secretary of the Institution of Electrical Engineers has been informed by the Central Electricity Authority, on behalf of the Area Boards, and by the South of Scotland Electricity Board and the North of Scotland Hydro-Electric Board that they are prepared to consider sympathetically applications from consumers, or contractors acting on their behalf, to follow the practice authorised in Regulation 105. Furthermore, where installations include a consumer's supply control unit complying with B.S. 1454: Consumers' Electricity Control Units, individual applications for authorisation need not be made, the bodies mentioned having stated that in the circumstances their agreement to the practice may be assumed.

Morgan Crucible Centenary

A hundred years ago the Morgan Crucible Co., Ltd., or as it was originally known, the Patent Plumbago Crucible Co., was formed which bought the manufacturing rights from an American company to manufacture its crucible in this country. A small factory was also purchased in Battersea, which is still the address of the company. To commemorate its centenary, the company has issued a well-illustrated book, "Battersea Works, 1856-1956," recording the history of the company and of crucibles. After dealing with the early days of the company, it traces the growth and the broadening of its activities which now also include the production of carbon brushes, lighting carbons and resistors for the radio and radar industry, for electronics and many other uses in the automobile, aircraft and electrical industries. The company changed its name to the Morgan Crucible Co. in the 1870's and in 1890 it was converted into a public limited company which now has branches and agencies all over the world.

Hydro-Electric Plant for Australia

A power plant which will be operated by remote control through a radio link from a station twelve miles away is to be equipped by the English Electric Co., Ltd., for the Electricity Commission of New South Wales. The new station is to be built on the Warragamba River, at a point about twelve miles from Penrith, as part of the Warragamba Dam hydro-electric project. The main purpose of the dam is to store water for supply to Sydney and the surplus water is to be used for generating power. The plant will be additional to the main power network in New South Wales and will be operated in conjunction with the network's steam stations either as a peak load station or for continuous running as the Electricity Commission decides.

The contract covers the installation of a 69,000 b.h.p. reaction turbine, directly coupled to a 62·5 MVA alternator, and this generating unit will be connected to the electricity network through a 62·5 MVA step-up transformer for transmission at 132 kV. Other equipment to be supplied includes a 250 kVA auxiliary transformer, the station crane, and all associated power cables, switchgear, control and communication equipment.

Irish Electrical Traders' Protest

In a letter to the Irish Minister for Finance, the Executive Council of the Society of Irish Electrical Traders points out that, on the introduction of the first import levy, it had occasion to protest against the effects of the drastic imposition of the levy on the electrical trade, setting forth its consequences in a memorandum then sent to the Minister. The letter to the Minister goes on to say:—

"The immense range and value of the second import levy embodied in the recent Order will only further accelerate the tendencies outlined in the Society's memorandum. The Society feels that the electrical industry and trade in Ireland have been called upon to bear an undue proportion of the burden. Irish electrical manufacturers are also, in the Society's opinion, seriously affected, as levies on component parts and accessories imported by them will increase their costs, thereby increasing the sale price to the Irish public of Irish-manufactured articles. It will, in the Society's opinion, retard the development of the electrical manufacturing industry, possibly discourage others from undertaking such manufacture, and preclude any possibility of developing an export market. The Society feels that the electrical trade should be given special consideration in the matter of import levies inasmuch as the continued and expanding use of electricity generated in great part from native fuel plays such an important part in the economic development of the country."

The import levy imposed as from 26th July amounts to 37½ per cent *ad valorem* under the full tariff and 25 per cent under the preferential tariff upon "electro-thermic and electro-mechanical appliances of a kind commonly used for domestic purposes, including appliances of a similar type for use in hotels, restaurants and institutions." In the case of many articles previously subject to a levy the respective rates have been increased from 37½ to 60 per cent and from 25 to 40 per cent.

Prices of Materials

In the accompanying table we give the basis prices of the more important materials used in the electrical industry. The figures given are the selling prices and are those quoted on Tuesday last.

ALUMINIUM ingots	ton £190 10s 0d
COPPER, H.C. Electro	ton £318 5s 0d
Fire Refined 99·70%	ton £317 0s 0d
Fire Refined 99·50%	ton £316 0s 0d
COPPER Tubes ..	lb 3s 0½d
Sheet	ton £386 5s 0d
H.C. wire and strip ..	ton £352 15s 0d
LEAD, English ..	ton £117 10s 0d
Foreign	ton £116 0s 0d
MERCURY	flask £84 0s 0d
TIN, block (English) ..	ton £767 5s 0d
ZINC, G.O.B. Foreign	ton £96 5s 0d
Electrolytic	ton —
BRASS Tubes (solid drawn)	lb 2s 5½d
Sheet	ton £311 0s 0d
Wire	lb 3s 1½d
PHOSPHOR BRONZE Wire	lb 4s 7½d
PLATINUM	oz £34 0s 0d
RUBBER, No. 1 R.S.S. spot	lb 32⅜d—32⅝d

Help for Exporters

We have received a copy of a special issue of the journal of the Advertising Association, 1, Bell Yard, London, W.C.2 (dated May, 1956), which bears the title "A Practical Guide to the Promotion of Exports." The contents are five articles dealing with market research; selling; advertising; colour, pack and presentation; and services that help the exporter, with a foreword by the editor, Mr. Roger Falk, O.B.E. Copies of the issue are obtainable gratis from the Association.

British Plastics Exhibition

Since the announcement that the next British Plastics Exhibition, being held from 10th to 20th July, 1957, is to become an international event, and will therefore include exhibits from other countries, so many requests for stand space have been received that the National Hall has been booked in addition to the Grand Hall at Olympia. Only a limited amount of vacant stand space remains, for which application should be made to the organiser, Mr. J. L. Wood, British Plastics Exhibition, Dorset House, Stamford Street, London, S.E.1. Overseas manufacturers who have already applied for space include firms in the United States, Germany, France, Italy, Switzerland and Czechoslovakia. A convention is being held concurrently with the exhibition and

details of this will be announced later. The exhibition and convention are organised by *British Plastics*, with the co-operation of the British Plastics Federation.

C.E.A. Contracts

Contracts have been placed by the Central Electricity Authority during the past month for power stations, transforming stations and transmission lines, amounting in the aggregate to £10,082,300. The principal contracts include the following:—

Belvedere power station, near Erith. Condensing and feed heating plants: Vickers-Armstrongs (Engineers).

Marchwood power station, near Southampton. Foundations for the oil handling and storage installation: Sir Robert McAlpine & Sons.

South Denes power station, Yarmouth. Superstructure: Richard Costain.

Drakelow "B" power station, Burton-on-Trent. Three generator transformers: British Thomson-Houston Co.

Elland power station, Yorks. Cooling tower: Davenport Engineering Co.

Blyth "A" power station. Two reinforced concrete chimneys: Holst & Co., Ltd. High pressure pipework and valves: Babcock & Wilcox.

Silsden substation, Yorks. 132 kV switchgear: British Thomson-Houston Co.

Bridgwater substation. Two 60 MVA 132/33 kV transformers: General Electric Co.

Capenhurst substation. 132 kV and multicore cables: W. T. Glover & Co., Ltd. Twenty-one 10 MVA 132/3·3 kV transformers: Ferranti.

Elland-Keighley and Elland-Halifax/Sowerby Bridge Tee. 132 kV overhead lines: Watsham's.

Drakelow-Penn-Redditch. 275 kV overhead lines: Watsham's.

Royal Lancashire Agricultural Show

The North Western Electricity Board's stand at the Royal Lancashire Agricultural Show held at Blackpool from 31st July to 3rd August gained the trophy for the best trade stand in the show. The exhibit was in three sections: "Electricity on the Farm," with a full-scale barn hay drying installation, in-bin grain drying, grinding, mixing, dairy and poultry equipment; "Electricity in Horticulture," emphasising electrical soil warming, propagation, irradiation lamps and automatic frost protection; and "Domestic Electrical Equipment."

Fire Protection Centre

The first Fire Protection Centre in Great Britain will be opened on 5th November at 19-25, North Street, Glasgow, C.3. The twenty-four sections and various sub-sections will display a collection of equipment covering fitting devices, systems and materials of every kind for the protection of life and property against the risk of fire.

Spraying Equipment Fatality

A strong recommendation that connections to all electrical appliances should always be done by a qualified person was made on 19th July by an official of the Midlands Electricity Board at the Hanley inquest on Mr. James Harvey, of 13, Tanners Road, Abbey Hulton, who received a fatal electric shock while spraying a car in the back garden of his home.

Mr. Thomas Brunt, a next door neighbour, said he disconnected the spraying equipment from the power point in the back kitchen and then applied artificial respiration.

Mr. T. C. J. Howell, commercial manager of the M.E.B., said he examined the spraying equipment and found it in good condition. He thought that the flexible wire was in poor condition, however, particularly in the circumstances in which it was being used. Mr. Howell said that a faulty connection where two flexibles were jointed contributed to the voltage being taken to the case of the instrument.

The jury returned a verdict of "Accidental death through electrocution."

Essay Competitions

The Council of the Institute of Marine Engineers is holding two essay competitions, in each of which a prize of £20 is offered for the best essay on any subject of marine engineering interest. One is open to members of any grade (including students and graduates), while the other is for students and graduates only. Essays must reach the secretary of the Institute by 1st October.

G.E.C. Laboratories Renamed

Three laboratories of the General Electric Co., Ltd., at Stanmore (Middlesex), Brown's Lane (Coventry) and Salisbury (South Australia), have been renamed under a group title of "Applied Electronics."

Reducing Radio-Telephone Costs

The problem of reducing the amount of radio-telephone terminal equipment required at exchange centres serving a number of outstation links, so that as little as possible remains idle for any length of time, is one that faces many overseas administrations. To meet this need a new system known as A.S.A.C. (automatic selection of any channel) has been introduced by the Automatic Telephone & Electric Co., Ltd., which more than halves the cost of terminal equipment, while at the same time providing normal exchange termination for each sub-centre, with no loss of secrecy.

Designed for use at exchange centres serving up to six v.h.f. radio links, A.S.A.C. consists of an automatic selection device which searches subscribers' links continuously by means of crystal switching, until a call is originated. The equipment can be used in conjunction with any type of exchange, manual or automatic.

Using duplex working, separate transmitter/receiver units are normally required for each end of a link, but by employing the A.S.A.C. system only two sets are needed at an exchange to serve six outstations. This enables two calls to be handled simultaneously, or alternatively a call via the exchange between two outstations.

Once a channel is taken into use, the searching arrangement is transferred to the second equipment, the engaged channel being by-passed during searching. A forced release feature is available to prevent the system being held indefinitely by one caller during busy periods. The system has been designed as part of the company's RL. range of radio equipment.

One of the first orders for A.S.A.C. equipment, which is being manufactured by A. T. & E. (Bridgnorth), Ltd., and was developed by British Telecommunications Research, Ltd., Taplow, has been placed by the Kuwait Oil Company for a radio system in Kuwait.

V.H.F. Sound Broadcasting

The B.B.C. announces that it is to proceed with the building of a further six v.h.f. stations constituting the second stage of the plan to provide nation-wide coverage on v.h.f. of its three sound programmes. These additional stations, together with the ten stations already authorised, will provide reception on v.h.f. of the Home, Light and Third Programmes for about 96 per cent of the population of the United Kingdom. Each station will carry the three programmes, except Corwen, which will broadcast the Welsh Home Service only; this area will receive the Light and Third Programmes satisfactorily from other v.h.f. stations and can also receive them on long and medium wavelengths. The new stations will be at Rowridge (I. of W.), Kirk o' Shotts (Central Scotland), Sandale (near Carlisle), Corwen (North Wales), Anglesey, and Rosemarkie (Moray Firth). It is hoped that the first four of these stations will be completed in 1957, and the other two during 1958.

Structural Engineers' Brochure

The Tees-side Bridge & Engineering Works, Ltd., Middlesbrough, has issued a well produced and illustrated brochure outlining its progress since it was formed in 1896. The company at first specialised in the manufacture of blast furnace and puddling plant, but now manufactures a wide range of products covering most classes of structural and general engineering products, including transmission towers, radio and television masts, oil storage tanks, conveyor bridges, etc.

Accident Prevention

The Royal Society for the Prevention of Accidents is holding a national industrial safety week from 5th to 10th November. The object of the campaign is to encourage all workers to be "safety conscious." During the campaign workers in factories throughout the country will be invited by means of special posters and other propaganda to look out for booby traps. The various local industrial

accident prevention groups will be organising special functions in connection with the campaign. The Society states that most of the larger industrial concerns in Britain are already enjoying the benefits of membership of the Society, and it is towards the numerous smaller factories and workshops with little or no safety organisation that its main efforts will be directed.

The Society has issued a pamphlet entitled "Beware of Booby Traps" illustrating posters which are available, "Your Guide to Booby Traps," containing a drawing depicting some of the dangers, in which workers are asked to spot the booby traps, and a number of leaflets showing how not to do a job. The Society's address is 38, Millbank, London, S.W.1.

Works Visit

On the occasion of the fourth meeting in London of the Commonwealth Military Communications Electronics Representatives a party of twenty-five Commonwealth representatives visited the New Southgate Works of Standard Telephones & Cables, Ltd., on 17th July for discussions and demonstrations of the latest types of ground and airborne radio communication and navigational equipments.

Sylvania-Thorn Building Award

At the International Festival of Architecture and Monumental Art (1956 Salon) held by the Société des Artistes Français, a first medal was awarded to G. A. Jellicoe & Partners for their design for the new Sylvania-Thorn colour television laboratories. This building, now nearing completion at Enfield, Middlesex, is the first in this country planned specifically for the development of colour television.

South African Traffic Signals Contract

A contract to supply equipment for the installation of twenty-six sets of vehicle actuated traffic signals at intersections in the city of Durban (S.A.) has been placed with the Automatic Telephone & Electric Co., Ltd. The signals are part of a major traffic reorganisation plan being undertaken by the Durban authorities. The equipment being supplied will include twenty-one of the latest "Electromatic" four-phase controllers, which are capable of controlling junctions where complex traffic movements are involved, and five of the normal two-phase types. Facilities are being provided to equip several of the installations with push-button units for pedestrians.

Plessey in the United States

To consolidate associations and agreements made with a number of United States companies in recent years, the Plessey Co., Ltd., has just formed an American corporation for the representation and control of its interests in that country. The new corporation, to be known as Plessey Incorporated, has been constituted under the laws of the State of Delaware. Offices are at 41, East 42nd Street, New York City. The Plessey offices in Chicago are being closed immediately and, in future, all the company's American affairs will be handled centrally through the New York headquarters. The president of Plessey Inc. is Mr. W. J. Sinsheimer.

Correcting Television Faults

A book which will be of value not only to the service engineer and dealer but also to owners of television sets has been published by Iliffe & Sons, Ltd., Dorset House, Stamford Street, London, S.E.1, for the *Wireless World*, price 3s 6d net (postage 3d). It is entitled "Correcting Television Picture Faults" (formerly "Television Picture Faults"), and is by John Cura and Leonard Stanley. In its sixty-nine pages there are over 150 "Tele-Snaps," mostly showing the result of various types of faults, but a few obtained under perfect conditions of reception are included for comparison. The various types of faults are dealt with under sectionalised headings, and the reader is easily able to identify any fault which may appear on his set. The cause of each fault is clearly explained—first in simple language which the ordinary viewer can understand, and then in greater detail (printed in different type) for the technician. Information on how to overcome the fault is given wherever possible. A glossary of control terms is included, and an index enables any item to be readily found.

Mobile Showroom

The accompanying picture shows the interior of a mobile showroom which Falk, Stadelmann & Co., Ltd., have recently put into service. The showroom has already visited the West Country, Kent and Lancashire and will shortly tour the Home and Eastern Counties. It has been designed to carry the company's new range of lighting glassware and contemporary lighting fittings, electric fires and other domestic appliances.

The interior of the new Falk Stadelmann mobile showroom

Technological Awards

The National Council for Technological Awards, Curzon Street House, Curzon Street, London, W.1, has issued an addendum to the memorandum on "Recognition of Courses in Technical Colleges leading to the Diploma in Technology." It contains paragraphs relating to fees and charges and to the submission of applications, and these replace paragraphs 23 and 24 of the memorandum.

Trade Announcements

The **Lincoln Electric Co.**, of Cleveland, Ohio, U.S.A., announces that it has terminated its association with Lincoln Electric Co., Ltd., of Welwyn Garden City, England. The sole distributor in the United Kingdom for all its products is now **Armco, Ltd.**, 75, Grosvenor Street, London, W.1.

Standard Telephones & Cables, Ltd., has established a regional office at Coronation House, 69-71, Market Street, Manchester, 1, under the management of Mr. A. W. Hadley.

The address of the Mechanical Handling Division of **Eccles (Birmingham), Ltd.**, is now: off Arrow Road, Redditch, Worcs (telephone: Redditch 3365).

Johnson & Phillips, Ltd., announce that the transfer of their Switchgear Department from Kidbrooke to New Cross is now completed. The new factory, known as Elizabeth Works, was acquired in 1954 and has been largely reconstructed to meet the demands for increased floor space and production facilities necessitated by the expanding activities of the Switchgear Department. The transfer will also release space at the main Charlton Works for the expansion of other departments. All correspondence with the Switchgear Department should continue to be addressed to the company at Victoria Works, Charlton, London, S.E.7. The Department's telephone number is now Tideway 5251.

Catalogues and Lists

MAGNESIUM ALLOY. — Publication entitled "Magnesium Alloy Pressure Diecasting" describing the properties of magnesium and advising on the design and machining of diecastings in this material.—**Stone-Fry Magnesium, Ltd.**, Brierley Hill Road, Wordsley, near Stourbridge.

POLES.—Leaflet (H.5) dealing with the company's range of "Hamilton" type poles for telegraph and transmission line supports.—**Poles, Ltd.**, Tyburn Road, Birmingham, 24.

TELEPHONES.—Folder dealing with "Strowger" private automatic telephone exchanges.—**Communication Systems, Ltd.**, Strowger House, 8, Arundel Street, London, W.C.2.

VARIABLE SPEED DRIVES.—23-page catalogue (F/3) dealing with the "F" type hydraulic infinitely variable speed gears.—**Carter Gears, Ltd.**, Bradford, 3.

ARGENTINE ELECTRICAL INDUSTRY

Growth of Local Manufacture

THE rapid increase in the industrialisation of Argentina is referred to in a report by Mr. A. H. Tandy, C.B.E., Minister (Commercial) at H.M. Embassy, Buenos Aires (H.M. Stationery Office, price 5s net). This has been most marked in electrical manufacture. Statistics published by the Central Bank show that the production index of electrical machinery and apparatus rose from 100 in 1943 to 369·9 in 1954. The industry enjoys Customs and other protection as an industry manufacturing essential goods for internal consumption and using domestic raw materials.

Dealing with the various classes of electrical equipment, Mr. Tandy says that large-size generators are not yet manufactured, but an Argentine firm has constructed for the first time a three-phase 13 kV a.c. generator of 15,000 kW. The maximum size of transformer so far produced is 2,000 kW. L.v. insulators manufactured locally are sufficient to meet the country's needs, but h.v. insulators are still almost exclusively imported. There is a fair-sized industry producing normal types of cables up to 33 kV, but coaxial cable and special types of high-voltage cables have to be imported. The manufacture of accumulators is sufficient to meet the domestic demand; this also applies to dry batteries.

Electric Motor Production

A considerable number of concerns make electric motors, the output having risen from 17,833 units in 1946 to about 44,000 in 1950. The principal emphasis of production is on fractional h.p. motors for fans. Motors of from 1 to 50 h.p. are almost exclusively of domestic manufacture. While some motors of from 100 to 1,000 h.p. are produced in Argentina, most machines of these large sizes are at present imported. Variable speed and other types are not made. There are several firms producing industrial furnaces; arc furnaces for the melting of steel and other metals are also made, but graphite electrodes have to be imported. Various types of electric welding machines are also manufactured.

On the domestic side, washing machines, electric cookers, water heaters, electric irons, fires and toasters are all manufactured in large quantities. There is only one manufacturer of complete refrigerators, but a number of concerns import sealed units and thermostats and incorporate them in cabinets of their own construction. Five lamp manufacturing concerns have an output which is adequate to cover domestic requirements, but practically all component parts, including capacitors, filaments and glass bulbs, are imported. Railway signal lamps, photo-flash lamps and mercury vapour lamps are not yet made. The manufacture of insulating tape is carried on with some raw materials produced in Argentina and some imported. The present demand, however, greatly exceeds output.

In the radio and television field no imports of complete radio sets are permitted, but some parts (valves, switches, volume controls, condensers of types not made locally) are imported. There are about 60,000 television sets in use at present, all of which have been imported; local assembly with some imported parts (cathode ray tubes, valves and certain capacitors) has begun and it is unlikely that further imports of complete sets will be permitted.

An appendix to the report shows that the value of imports of electrical machinery, apparatus and appliances from the United Kingdom during the years 1952 to 1954 was as follows:—1952, £1,651,463; 1953, £983,964; and 1954, £1,030,041.

Electricity Generation

As a result of industrialisation and the growth of towns, the demand for electricity has outrun supply throughout the country, and although output of power in 1954 was 5,369 million kWh, as compared with 2,976 million kWh in 1945, existing capacity is altogether inadequate and in the Greater Buenos Aires area, which consumes 72 per cent of the country's total output, there is frequent load shedding and capacity is at least 300,000 kW short of requirements. New industrial enterprises in Greater Buenos Aires must apply for an authorisation to use electric power, which is, in practice, only granted for night work. There has hardly been any extension of street lighting, and commercial lighting for display windows, showcases and advertising purposes is restricted. There are similar shortages in Rosario and Cordoba, which in the latter area threaten to retard industrial development. The generating capacity in Argentina is estimated at about 1,860,000 kW of which thermal plants account for 1,340,000 kW and hydro-electric plants 120,000 kW, the balance being produced by diesel power.

Electric power was partially nationalised in 1946, when the Department of Water and Power was formed and took over a number of existing power plants. Attempts are now being made by the Government to increase capacity. It is estimated that not more than 290,000 kW of hydro-electric capacity will have been installed by the end of 1957. The largest power project is the " 24 de Febrero " thermo-electric station at San Nicolás on the Paraná River (Buenos Aires Province), which is being built by German firms. The station will consist of four 75,000 kW turbo-generators with two sets totalling 20,000 kW as auxiliaries. Plans have also been drawn up to increase the capacity of the Buenos Aires plant of the Compañia Argentina de Electricidad (CADE) from 600,000 to 850,000 kW and of the Compañia Italo-Argentina de Electricidad from 180,000 to 260,000 kW. After the fall of Perón the provisional Government announced that it would reconsider the 750,000 kW Salto Grande hydro-electric scheme on the Uruguay River which had been shelved on account of political difficulties.

In a postscript to his report, Mr. Tandy says that the Rosario Municipality and the Government of the Province of Santa Fé have taken over the Sociedad de Electricidad de Rosario and the enterprise will be administered and operated by the National Power Administration. Representatives of various political parties have expressed themselves in favour of annulling the concessions granted in 1936 to the Compañia Argentina de Electricidad and the Compañia Italo-Argentina de Electricidad.

The Argentine Atomic Energy Commission is carrying out elementary atomic energy research at its Buenos Aires establishment. According to the Government's present plans, two atomic power plants are to be built, the first to be completed by 1968 and the second by 1980, by which time it is hoped that half the power capacity of Argentina, or approximately 2½ million kW, will be represented by atomic plant.

Electronic Machine Tool Control

HORIZONTAL BORING MACHINE WITH AUTOMATIC CO-ORDINATE SETTING

SOME two years ago the British Thomson-Houston Co., Ltd., commenced the development of automatic co-ordinate setting for boring machines, and the first commercial installation was completed several months ago at the Leicester factory of the British United Shoe Machinery Co., Ltd. The work has been successfully carried out in close co-operation with H. W. Kearns & Co., Ltd., the automatic controls being applied to a Kearns No. 0 planer table type horizontal boring machine.

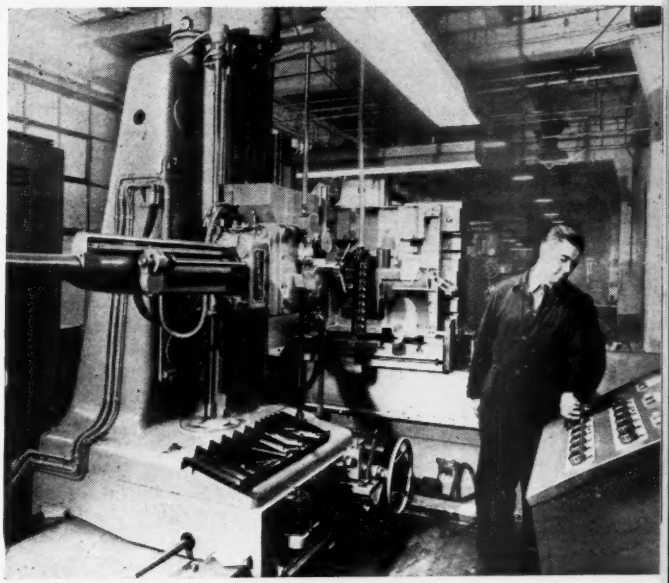
Essentially the co-ordinate setter comprises servo-mechanisms operating the horizontal and vertical slides of the machine, which have traverses of 57in and 42in respectively. The slides can be set to any position by setting up the co-ordinates on the control desk dials. Six dials and clearly displayed figures are provided for each of the two ordinates, to set up any required displacement (e.g. 12·3456in) from a predetermined datum. This feature is appropriate to very short run production and tool-room class of work generally, and results in marked time saving as the operator is relieved of the duty of reading and adjusting to finely graduated scales, or handling of length-bars.

For longer runs the slides can be set up by a card reader on the operator's control desk using one punched card per hole centre. Automatic clamping of the slides is provided when the desired co-ordinate position is reached.

The blue-print (which may not be required on the factory floor so far as the boring operations are concerned) will show dimensions with respect to two datum lines convenient to the particular workpiece. To simplify setting up procedures, the co-ordinate setter includes means for changing quickly the datum of measurement for each traverse. The wide speed range servomechanisms necessary for co-ordinate setting provide a convenient feed drive for milling operations, suitable controls for which are provided.

The card reader unit serves to shift the hand setting dials, thereby giving a check, if necessary, on the accuracy of card reading. Identical servo-systems are used for both traverses and it is therefore sufficient to describe operation from the dial shafts on the operator's desk, to the control of one motion. The electrical measuring system on the machine tool table comprises a rigid measuring bar accurately divided into one inch units by holes spaced 1in apart along its length. An electromagnetic sensing head, mounted on the bed of the machine tool, co-operates with the bar and provides an electrical misalignment signal to the control system. The electromagnetic unit is capable of being shifted by a micrometer screw and an accurate instrument servo through any displacement up to one inch.

Thus the measurement bar may be regarded as providing accurate measurement of the integral inches part of a required co-ordinate shift, while the decimal part is accommodated by accurately controlled shift of the sensing head.



General view of the installation

In more detail the controlling action is as follows, described as a sequence, though in practice certain motions take place simultaneously. It will be assumed that the required co-ordinate has been set up on the six dials. Through suitable gearing the "input" synchros S_1 S_2 S_3 S_4 are rotated, and give misalignment signals in co-operation with the corresponding "output" synchros T_1 T_2 T_3 T_4 respective

The decimal dimension is defined by shaft rotation of S_2 S_3 and S_4 which causes the servo-amplifier A to operate motor M, until S_2-T_2, S_3-T_3, S_4-T_4 are in alignment. High quality instrument gearing and an accurate micrometer screw shift the electromagnetic unit through the required decimal dimension.

The integral part of the desired co-ordinate (with a contribution from the decimal part) gives a rotation of synchro S_1 which is interconnected with synchro T_1 geared to the lead-screw. A misalignment signal from S_1-T_1 controls servo-amplifier C and via the motor M_2 brings the table to within about 0·2in of the desired position, the traverse speed being maintained at about 120in per minute until the last inch or so of travel is reached, after which the speed is progressively reduced. Control of M_2 is now transferred (via servo-amplifier B) to the electromagnetic head. The control signal from the latter drives M_2 until the poles of the magnetic head are aligned opposite the nearest hole in the bar, under which conditions the error signal from the magnetic head becomes zero.

During the approach to alignment under the control of the electromagnetic head, a temporary misalignment signal is injected into amplifier B, so that the table travels to a "false alignment" position, approximately 0·2in from true alignment. The temporary signal is then automatically removed and thus the final approach to alignment is always from the same direction. The error signal from the magnetic head is proportional to displacement from the desired position, and reverses in phase for an error in the opposite direction. This permits the final approach to alignment to be made under conditions of controlled velocity and retardation of the table, so that the manner of stopping is predetermined by the electronic

circuits, and not by extraneous conditions such as viscosity of lubricants, table loading, etc.

After the setting of the digit dials—by hand or card—the automatic setting of both co-ordinates on the machine tool is initiated by push-buttons, and the sequence ends by the automatic clamping of both motions.

The measuring bar is of heavy construction in a special steel and carries the "inch units" which are identical blocks with a $\frac{3}{4}$in dia. hole in the face. In order to present a smooth face the holes are filled with brass inserts. The bar is set up in a temperature controlled measuring room so that the reference holes are 1·000in ± ·0002in apart. A final screwdriver adjustment is available, which through the medium of an asymmetrical steel slug in the bar allows the effective magnetic position of each hole to be shifted up to ± ·0005in. The final adjustment is preferably left until the bar is in position on the machine tool.

Electromagnetic Unit

The electromagnetic head is essentially a differential arrangement of two transformers, the magnetic circuits of which are completed by that part of the measuring bar which faces the head.

The construction of the head is symmetrical so that it is free of changes caused by temperature, supply voltage and frequency variations, and stray magnetic fields. The gap between the magnetic head and bar is not critical. The sensitivity of the head is such that it is capable of delivering a sufficient voltage to operate the servos with 20 micro-inches misalignment from the magnetic centre of one of the reference holes in the bar and it carries oiled felt pad wipers which clean the face of the measuring bar.

As previously stated the sensing unit in the head is shifted by the decimal part of the co-ordinate desired, and accordingly it is carried on a short accurately made slide, parallel with the measuring bar. A high accuracy electronic servo effects the positioning through the medium of a gear box and micrometer screw. As shown in Fig. 1, coarse, fine and very fine synchro data units are used to attain high accuracy. While reliance is placed on the accuracy of a micrometer screw to shift the electromagnetic head, it must be remarked that the only force on the screw is that to move a mass of a few ounces in carefully made slides.

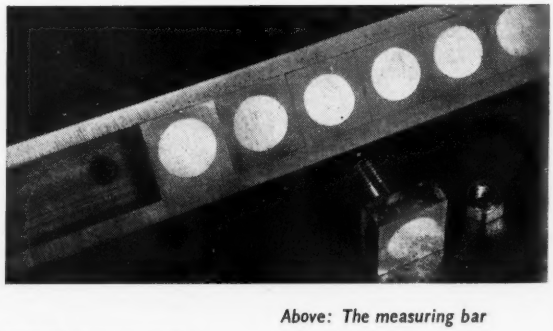
The control desk may be situated at the most convenient position to suit the machine tool operator. Appreciable space on the desk is allocated to the digit set up dials, on the shafts of which detent action gives positive location for each of the ten decimal positions.

Referring to Fig. 1, it will be seen that the synchros S_1, S_2, etc., are not operated directly by the dials, but through differential gears and other gearing of appropriately chosen ratios. The differentials serve to add one-tenth of the rotation of any dial to that of the shaft behind the adjacent dial on its left-hand side. This is necessary, firstly, because in the coarse, fine and very fine data transmission between the desk and the micrometer servo, there is a fixed relationship between the rotors of T_2 T_3 and T_4 through a normal gear train. The same apparent relationship must therefore hold between the shafts of S_2 S_3 and S_4 in order that alignment of S_2 to T_2, S_3 to T_3 and S_4 to T_4 may take place simultaneously and unambiguously wherever the dials are set. It would not be satisfactory to gear the dials together directly; with such an arrangement the right-hand dial would need to make a thousand revolutions for every inch change of setting. This would neither be convenient nor speedy. It is preferable that, to the operator, the dials should appear to be independent.

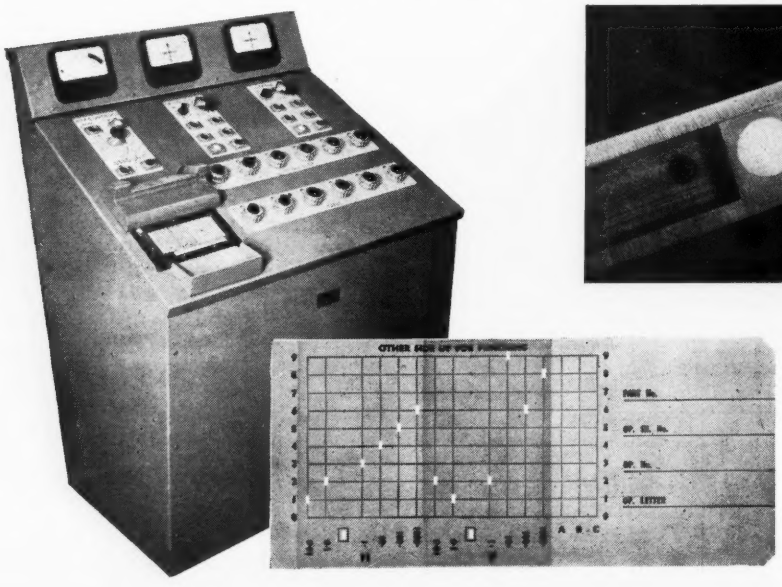
Secondly, differential coupling is also used to the left of the decimal point. This is to ensure that no ambiguity arises if the input dials are changed from say 12·0000 to 12·9999. This would cause the electromagnetic head to be moved very nearly into alignment with the 13th unit on the measuring bar, but it must not be aligned with this unit, but with the 12th. Therefore, the synchro S_1 is rotated by an amount which corresponds approximately to 0·9999in and through the main servo motor M_2 brings the table nearly to the correct position as described previously.

The card reader can be seen on the left-hand side of the control desk. Standard size business machine cards are used, but made of a material which is impervious to oil. They can be prepared for use by means of a simple hand punch and identification and operator's instructions are written or printed on each card, one card being used for each pair of co-ordinates. A typical card is illustrated.

In operation a card is taken from a stack and placed on the carriage. A "start" push-button is pressed which causes the carriage with the card on it to be drawn into the reader. Simultaneously, the dials are automatically



Above: The measuring bar



Left: Close-up of control desk and a typical card

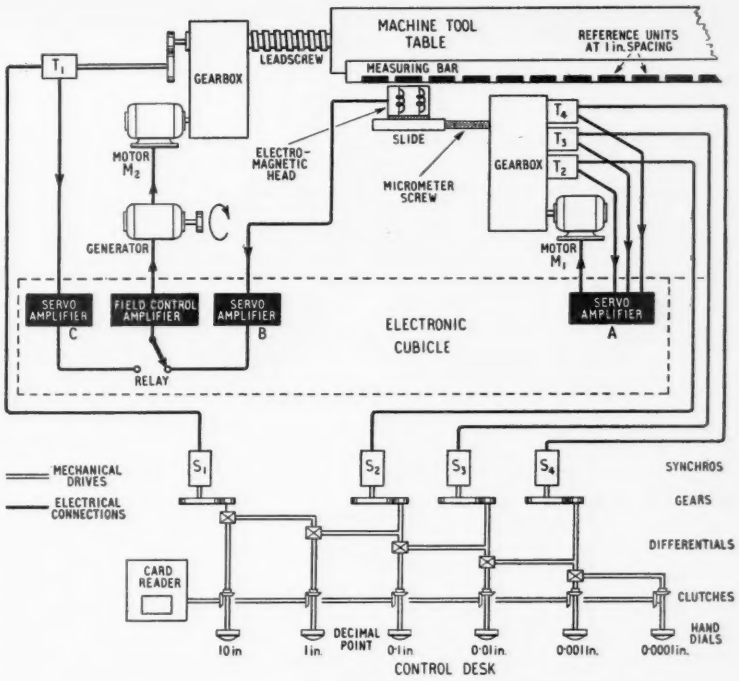


Fig. 1.—Diagram of control system

returned to their zero positions. The carriage then reverses its direction of movement and brush contacts are lowered on to the card. As the card is returned to its start position, the dials are rotated in unison. The brushes can complete electric circuits through the holes in the card and when any one brush makes contact, the appropriate dial is disengaged from the driving mechanism and is left accurately positioned by means of a detent wheel and spring loaded arm.

In addition to automatic co-ordinate setting, milling feeds are available, and advantage is taken of the servo system in providing continuous adjustment of feeds from ½in to 10in per minute. Three meters are mounted on the desk, one indicating spindle horse power and the other two indicating when coincidence has been achieved between the machine tool slide positions and the numbers set up at the desk. These are used principally for setting the datum for measurement, but may also be used as a means of checking that correct positioning has been achieved.

Machine Tool Design

The machine consists of a main bed 10ft long carrying a table 3ft by 6ft, on which is mounted a cellular constructed revolving table 3ft square. In view of the length of the main bed, the table is fully supported throughout the full length of this traverse.

Built into the main table is an easily revolving mechanism for lifting the revolving table, to reduce the effort required for rotation. At both sides and at right angles to the main bed are auxiliary beds each 4ft wide across the ways and carrying the upright and boring stay bases respectively. These bases can be traversed longitudinally a distance of 2ft on their beds to give a total distance between the spindle nose and boring stay of 7ft 6in.

In the case of the upright base, which carries the upright and spindle slide, this can be traversed rapidly by a built-in stator and rotor unit in addition to which a full range of sixteen reversible power feeds is available. The upright carries the spindle slide in which is incorporated the change speed and feed mechanism for the longitudinal traverse of the spindle and upright base.

The travelling spindle is of nitrided steel and slides in a nitrided cast iron bush, within a sleeve of forged steel, which rotates in precision ball and roller bearings. A range of sixteen reversible speeds is available to the 3in diameter spindle and these are selected by only two levers. The 5 h.p. stator and rotor unit is mounted in the base of the upright and drives the change speed gear box in the spindle slide through a constant speed vertical shaft.

The feed mechanism to the longitudinal traverses of the spindle and upright base embodies a patented arrangement whereby two complete ranges are available. One is driven from the spindle sleeve and gives eight feeds in cuts per inch. The other is driven from the first motion drive shaft and gives eight feeds, independent of the spindle speed, in inches per minute.

The main drive motor is controlled by an automatic contactor direct-on-line starting panel housed in the back of the upright.

In designing this machine, H. W. Kearns & Co. have been conscious of the problems involved, not only in utilising the accuracy available in the electronic co-ordinate setting system, but also in maintaining it throughout the life of the machine. In an attempt to achieve these objects the transverse movement of the main table is obtained by mounting the gear box direct on the end of the main bed, thus giving a direct drive via a constant length shaft and two large diameter coupled worms, to a segmental phosphor bronze nut, attached to the main table. This gear box, in addition to providing the drive for automatic positioning, gives an infinitely variable range of feeds from ½ to 10in per minute, also rapid traverse at a rate of 120in per minute.

Of vital importance is the type of lubrication system, its application and the lubricant used. The table lubrication is provided by a motor driven oil pump with independent feed regulators to the various points. A number of large sectioned interconnected oil grooves, at right angles to the line of travel, are machined in the main table. The motor driven oil pump is interconnected with the control pendant and operates automatically whenever the table is traversed.

The vertical movement of the spindle slide is also directly under the control of a gear box which is mounted on the top of the upright and directly coupled to a large diameter vertical screw. This box provides the drive for automatic positioning, together with the range of feeds and rapid traverse motion similar to the main table.

As in the case of the main table, exceptionally long narrow guides are used on the spindle slide. Lubrication on the spindle slide is carried out in a similar manner to the table, the lubricant being supplied by a separate hand operated pump.

Exceptional care has been taken in the design and preparation of suitable supports for the measuring bars and electromagnetic detector heads which are used for automatically positioning the vertical adjustment of the spindle

slide and transverse movement of the table. In both cases large H-section cast iron girders are used for carrying the measuring bars. This system not only ensures the maximum degree of accuracy from the measuring equipment, but is also of considerable importance during the installation and maintenance of the machine.

The control pendant carries ten push-buttons. Three of these control the main spindle motor giving start/forward, start/reverse and stop, an electrodynamic braking system being used for stopping the spindle. Three further buttons control the inch/forward, inch/reverse to transverse movement of the table, and the start of automatic positioning. Three buttons are also provided to give a similar control to the vertical movement of the spindle slide. The remaining push-button stops the spindle slide and table movement.

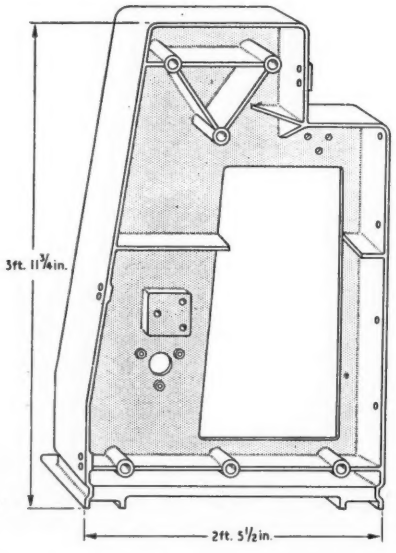
In order to ensure the holding of a slide which has reached the required position, hydraulic clamps automatically operate on the spindle slide, table, and boring stay bearing. The hydraulic clamping unit is carried in a steel cabinet alongside the machine. Solenoid operated valves control the oil circuit which operates the hydraulic cylinders. Maximum clamping efficiency is obtained by the use of a wedge lined and bushed by plates of p.t.f.e. material. Two of these clamps are provided on the spindle slide and one each on the transverse movement of the table and vertical adjustment of the boring stay bearing.

To ensure that no distortion takes place on the main sliding surfaces the hydraulic locks operate through a friction material with independent strips attached to the main casting.

The vertical adjustments of the spindle slide and boring stay bearings are synchronised mechanically but, if required, the boring stay bearing can be realigned vertically through a worm wheel mechanism operating on the screw nut.

The accuracy required for the installation described here is ±0·0005in but ±0·0002in is achieved in practice. By using very accurate micrometer screws for positioning the detecting heads, and by taking advantage of the facility for fine adjustment of the 1in units on the measuring bar, the equipment is capable of ±0·0001in. The measuring bars are set at 68 deg F, and have the same temperature coefficient as cast iron. Consequently, variations of shop temperature do not produce discernible errors when working on this material.

A second Kearns planer table type horizontal boring machine has been constructed with the British Thomson-Houston automatic co-ordinate setting system and was shown at the recent International Machine Tool Exhibition.



A typical task accomplished on the machine described. The work involves six holes drilled and counter-bored, nine holes drilled and tapped, and eleven holes drilled. The total time for marking out and drilling by previous methods was 4 hr 34 min. The new machine completes the task in 2 hr 17 min

Anglo-German Atomic Agreement

AN agreement for co-operation on the peaceful uses of atomic energy was signed in London on 31st July by Mr. Selwyn Lloyd, the Secretary of State for Foreign Affairs, and Herr Hans von Herwarth, the Federal German Ambassador. Herr Franz Josef Strauss, Federal German Minister for Atomic Affairs, and Sir Edwin Plowden, chairman of the United Kingdom Atomic Energy Authority, were present at the signature.

Under this agreement the Federal Republic of Germany may obtain, on terms to be agreed, research reactors and the necessary fuel elements, and unclassified information on topics to be agreed concerning the design, construction and operation of these reactors. The Atomic Energy Authority will, wherever possible, provide facilities for training, and the parties to this agreement will help each other to obtain the research quantities of materials needed for their atomic energy programmes. The Germans will probably purchase from British industry a research reactor of the "swimming pool" type and a high-flux research reactor for testing materials similar to the "Pluto" reactor under construction at Harwell.

The agreement states that reactors, materials and information supplied will be used for peaceful purposes only, and provision has been made for safeguards to ensure this. The parties to the agreement recall their intention to support the International Atomic Energy Agency. When the Agency has been set up, they will consult with each other about the possible application of Agency controls in respect of the present agreement. The agreement is for ten years and may be renewed for further periods.

Insulation of Power Transformers

A NEW publication of the British Electrical and Allied Manufacturers' Association, "The Insulation Level of Power Transformers," has been prepared by the Association's Transformer Technical Committee, based on the studies of the Committee and its reports during recent years to the Transformer Section on whose behalf the publication is now issued.

The recommendations are intended to meet requests for guidance on the selection of insulation level, of power frequency and impulse-voltage test values and on test procedures pending the publication of national standards by the British Standards Institution in a revision of the present B.S. 171, "Electrical Performance of Transformers for Power and Lighting."

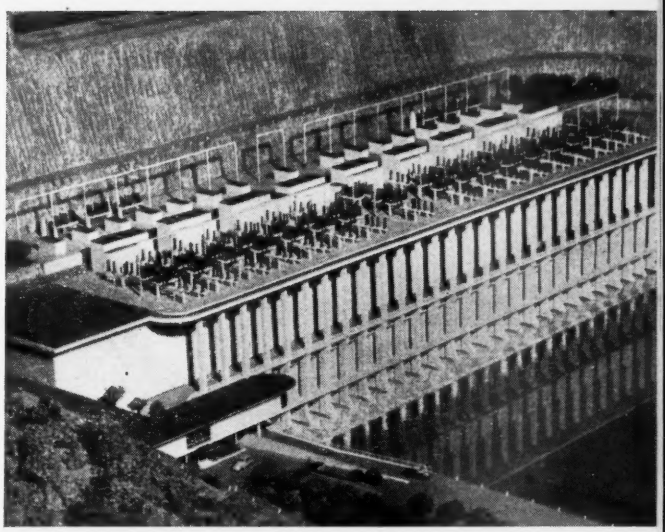
The work is in six parts under the following headings: "Selection of Insulation Level," "Grading of Insulation to Earth," "Tests and Tables of Test Voltages," "Procedure during Power Frequency Tests," "Procedure during Impulse Tests" and "Information to be given with Enquiry and/or Order." These sections are supported by tables on system voltages, dry type transformers, oil immersed transformers, electrically non-exposed transformers, electrically exposed transformers—system highest voltages up to and including 61 kV r.m.p., electrically exposed transformers—system highest voltages exceeding 61 kV r.m.s., line end of windings, neutral end of windings, test voltages, non-standard duration, and spacing of standard rod gap.

Power for Aluminium Production

Report on the Volta River Project

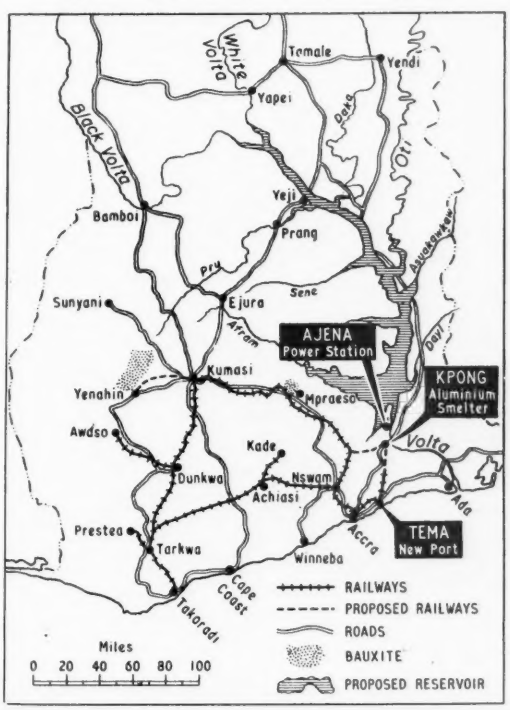
FOLLOWING the publication of a White Paper in 1952 on the Volta River hydro-electric/aluminium production project, the British and Gold Coast Governments set up a Preparatory Commission to examine the plan. The scheme envisages the construction of a 600,000 kW hydro-electric station to supply power for the manufacture of aluminium, the parties concerned being the two Governments, the British Aluminium Co., Ltd., and Aluminum, Ltd., of Canada.

In its report now published* the Commission says that a successful outcome of the project would have beneficial results for all concerned. It could make available to the Sterling Area a further supply of aluminium far in excess of the Area's present production, saving about $100 million annually. New and very large capital assets would be created in the Gold Coast and the country's economy would no longer depend on a single export—cocoa. On the other hand failure would have most serious repercussions. The Commission finds however, that all the elements for success are available and says that the project can be regarded as technically sound. Since the cost of power and of rail freights would diminish sharply with increasing aluminium production, the greatest return would be derived by achieving maximum output as soon as possible. The project should be competitive in relation to other schemes provided it is completed according to the timetable, a sound policy is adopted in the employment and provision of living accommodation for the labour force, the economic stability of the Gold Coast is maintained, and the aluminium companies are satisfied that the internal cost of operating the smelter would be acceptable.



Model of the proposed power station

Map showing the sites of the principal developments



The main works involved are the development and operation of new bauxite mines; the building of some 83 miles of railways; the construction of a dam (which would create a lake covering an area of approximately 3,500 square miles) and power station; the building of a factory and smelter with an ultimate annual capacity of 210,000 tons of aluminium; and the construction of new roads and townships.

Bauxite would be obtained from deposits, estimated at 200 million tons, in the area of a range of hills some 35 miles west of Kumasi. The bauxite would be extracted by opencast mining similar to that already employed by the British Aluminium Co. at Awaso. The best position for the smelter is considered to be in the Kpong area where in 1954 representatives of the aluminium companies chose a site north of the Somanya-Akuse road. A working force of about 9,000 would be required and, with their dependants and the people to provide goods and services, this would lead to the building up of a township of about 50,000 population. A new port is essential. The Gold Coast Government however, has already decided to go ahead with the construction of a deep-water harbour at Tema, 17 miles east of Accra. The main contract, amounting to £7½ million, was let in 1954 and a new township is in course of construction at Tema.

A chapter of the report on the technical aspects of the dam and power installation summarises the proposals of the consulting engineers, Sir William Halcrow & Partners, which are given more fully in a separate engineering report.* They recommend the construction of a rockfill dam with a crest 4,100ft long and with a height of 310ft above the river bed in the deepest part. The power system on the eastern flank of the dam would consist of a forebay with control gates, and steel-lined tunnelled penstocks

* "The Volta River Project. 1. Report of the Preparatory Commission." H.M. Stationery Office, 35s. 2. "Appendices," 110s. 3. "Engineering Report by Sir William Halcrow and Partners," 175s.

leading to a power station and tailrace. A natural saddle on the east flank, to be deepened by excavation and in which there would be constructed a concrete weir with control gates, would provide a spillway capable of dealing with all possible floods. It is proposed to increase the head produced by cutting a channel 300ft wide and 28ft deep through the Senchi Rapids 8 miles downstream, and at a later stage by forming an additional small cut in the crest of the Kpong Rapids 5 miles below Senchi.

After allowing for an annual abstraction of water for irrigation not exceeding 710,000 acre-ft it is considered that the flow from the reservoir can be regulated to provide a firm output of 617,000 kW of continuous power. Alternatively, if the project were allowed to develop its full power and any irrigation water needed were pumped, using power derived from the station, a firm output of 633,000 kW could be generated. It is proposed that the power produced should be transmitted at 165 kV to the smelter. The services of Mr. G. A. Jellicoe, F.R.I.B.A., were retained to prepare general layouts and perspectives of the power station, a photograph of a model of which is reproduced. In view of the national significance of the various works it was agreed that a traditional indoor station should be built rather than a more utilitarian " outdoor " structure.

The consulting engineers recommend that the first stage of the power scheme should provide for the installation of four units each consisting of a Francis turbine and 90 MW generator, with one double-circuit transmission line to Kpong. Each of the succeeding stages would require the installation of two further units of the same size.

Based on prices ruling at 30th September, 1955, the capital cost of all the hydro-electric works, including transmission, and inclusive of interest, is estimated at £60¼ million for the first stage, a further £3¾ million for the second stage and £3½ million for the final stage. It is considered that if construction of the dam is commenced not later than mid-1957, and with normal rainfall in the catchment, the reservoir should fill to a level sufficient to produce first power early in 1964 and full power for the first stage of development by the middle of 1966.

The creation of a lake so large as that proposed would obviously give rise to many problems and these are dealt with extensively in the report. The Commission estimates that the cost of compensation and resettlement would be about £4 million and recommends that a further £500,000 should be accepted as a prospective liability for the effects on communities downstream from the dam. At present, some 62,500 people inhabit the area which would be submerged by the new lake. Fortunately, the greater part of the area is sparsely populated and there is relatively little cultivation. With the exception of a small limestone deposit, no minerals of commercial significance are known to exist.

Cost of Scheme

The financial and economic aspects of the Volta River scheme are examined in Part III of the report. The total estimated cost of the initial stage, providing for an annual production of 80,000 tons of aluminium, is £162·6 million (This compares with an estimate of £100·5 million in the 1952 White Paper.*) The overall figure includes £60·2 million for the dam and power installation, £43·1 million for the smelter and mines, £15·9 million for railways, £2·5 million for other direct commitments, £1·5 million for other possible investments and £39·4 million for allied development expenditure.

The intermediate stage, to bring the annual output up to 120,000 tons of aluminium, would raise the cost to £184·9 million (1952 figure, £114·5 million) and the final cost on completion of the final stage (210,000 tons of aluminium a year) is estimated at £231·3 million (1952 figure, £144 million).

These estimates are based on an interest rate of 5 per cent and indicate that the cost of power from the first stage would be 0·378d/kWh; at the second stage 0·245d; and at the final stage 0·199d. The Commission believes that power at this price would be fully competitive with that produced from any other schemes of similar magnitude recently completed or under consideration. Having regard to economic conditions during the past decade it is thought prudent to allow for an increase of the order of 40 to 50 per cent in the estimates but this would be offset by any increase in the price of aluminium and the competitive position would be unimpaired.

Other Developments

As 90 per cent of the power from the project would be required for aluminium production, an appreciation was made of the possible long-term needs of the country for power and an investigation was made of the Black Volta at Bui about 120 miles from Kumasi. The consulting engineers consider that this could be economically developed and suggest the installation of 120 MW, with allowance for an additional set of 40 MW. The total capital cost, including transmission, would be £19,351,000 and the average cost of supplying this power at Kumasi would be 0·57d/kWh. Short-term requirements would be dealt with by a new thermal station at Tema from which first power should be available in 1959.

The two Governments and the aluminium companies have each reaffirmed their interest in the Volta River project. The International Bank has been invited to back the scheme and will send a mission to the Gold Coast this year to survey the country's economy.

* *Electrical Review*, 5th December, 1952.

Atomic Energy Inventions

THE United Kingdom Atomic Energy Authority is taking steps to bring to the notice of industry many of the developments and inventions which have arisen out of the work of its Research and Industrial Groups. The Authority now has a substantial holding of patents and patent applications which may be useful not only in the development of nuclear power but also for more general purposes in the chemical, engineering, metallurgical and electronic instrument fields.

A staff of patent officers, attached to the Atomic Energy Establishment and the Industrial Group, works closely with the scientists and engineers in assessing the value of inventions and taking appropriate action to patent them. In filing details they also give indications of the uses which might be made of the inventions in other industries. Mr. Thomas Benson Gyles has been appointed by the Authority to act as a liaison officer with industry, and to advise on the uses to which these inventions might be applied and the terms (on a non-exclusive basis) under which they can be used.

Mr. Benson Gyles, although a member of a St. Ives family, was born in Australia, and graduated at Melbourne University. He was with the Imperial Smelting Group for 19 years, was a member of the Control Commission in Germany for seven years, and from 1952 until 1955 was general superintendent of the Sindri Fertilisers & Chemicals, Ltd., in India, where he also acted as a United Nations consultant on the organisation of nationalised enterprises in Asia working with other international representatives.

Engineering in Europe

ABSTRACTS FROM FOREIGN TECHNICAL JOURNALS

EXPERIMENTS on simple knife-switches stressed by permissible short-circuit currents (up to 25 kA) enabled thermal stressing, heat transfer and contact resistance relations to be determined by measurements with thermo-couples and oscillographs. Within a certain range the phenomena were in good agreement with theoretical predictions due to Binder. Above all, it was found that the contact heated up within about 0·04 sec, when equilibrium between heat produced and transferred (or dissipated) was established. The contact resistance rose to its maximum within about 0·09 sec and the energy dissipated then fell whereas the temperature rose further (to about 100 deg C). Voltage and contact resistance also fell, this indicating an extension of the contact area at the point of the " contracted current path." This is due to a yield or flow of the contact material and leads to a reduction of the current heat (Joule's heat) and the temperature. The latter causes the material to re-solidify, this being indicated by a renewed increase of the contact voltage, resistance and current density (because the contact area is again reduced by the contraction of the solidifying contact materials). The whole process may be repeated several times during a test lasting 1 sec.—" Phenomena in Switch Contacts Stressed by Short-Circuit Currents," J. Wrana, *Dtsch. Elektrotech.*, Vol. 10, No. 6, pp. 207-211, June, 1956, in German.

Spark Machining

The temperatures of sparks produced by a spark-machining installation were measured by Ornstein's method on the Fe II-lines. A new method of measuring the spark temperatures by comparing the relative intensities of the spark and arc lines of iron was also evolved. The relations between spark temperatures and the parameters of the installation, electrode materials and diameters were investigated at first on electrode combinations of iron with other metals and carbon, respectively. The main results were that in combinations of iron with other metals, spark temperatures are almost independent of the material of the second electrode, but are lower by 600-1,000 deg for the combination Fe-C; the temperature of the spark between Fe-electrodes is practically independent of supply voltage and charging current in the range 70-220 V and 1-3 A. The relation between spark temperature and capacitance of the capacitors of the installation may be expressed by the formula $T=7{,}200+450\sqrt[3]{C}$. Arc temperature increases considerably with decreasing electrode diameter.

The second part of the paper reports investigations of the spark spectra in arc-machining installations carried out on 377 electrode combinations, viz. the elements Be, C, Mg, Al, Si, Ti, Cr, Fe, Co, Ni, Cu, Zn, Mo, Ag, Cd, Sn, Sb, W, Pb, Bi; the composition of the vapour-phase as influenced by operating conditions, duration of process, polarity, porosity and shape of the electrodes, and the effect of selective evaporation, was studied. The decisive role of the thermal effect in the processes of spark-machining was again confirmed. The composition of the vapour-phase depends mainly on physico-chemical characteristics of the electrodes. The machining process does not affect the vapour-phase. The anode element prevails in the vapour-phase.—" Investigation of the Temperature of the Vapour-Phase Produced in the Spark-Machining of Metals; Use of Spectrum Analysis for Investigating the Vapour-Phase Produced in the Spark-Machining of Metals," L. S. Palatnik and A. N. Lyulichev, *Zh. tekh. Fiz.*, Vol. 26, No. 4, pp. 832-838, 839-849, 1956, in Russian.

Readers who require accurate full translations of any of the articles abstracted in this section can be put into touch with the translators who will supply them at current rates.—Editors, *Electrical Review*.

Eliminating Transmission Faults

The fault statistics of Electricité de France have shown that each of the 292 circuit-breakers serving 9,726 km of 225 kV lines operated during 1954 on an average for 24 seconds, and the 593 breakers installed on the 9,263 km of 150 kV lines on an average for 16 seconds during the whole year. This corresponds in the first case to 12 operations; in the second to 8 operations. This bad utilisation of the switchgear, especially if the figures are taken as representative for the total of 7,124 circuit-breakers installed in the whole system of the E.D.F., constitutes a considerable economic loss and it is not surprising that efforts were made to find ways for cutting down the huge investments on circuit-breakers.

It was clear from the beginning that the majority of the breaker operations were required to clear intermittent faults and this was also confirmed by special investigations and experiments carried out on certain lines and in the Research Station, Fontenay, in which subsequently a new method of clearing intermittent faults was evolved. It is based on the relatively simple idea of shunting, instead of isolating, arcing faults, first tried in the U.S.A. as long ago as 1911. This method has some inherent advantages in that it protects insulators against damage by flashovers and reduces surge voltages due to arcing grounds. The idea, however, that the systematic application of this principle can result in a reduction of the numbers of circuit-breakers required and lead to entirely new concepts on economic system protection, is original, and was demonstrated by very interesting and conclusive experiments of the French engineers which are reported in full in the article.—" A New Method of Eliminating Intermittent Faults in Transmission and Distribution Systems," L. Cabanes, Ch. Dietsch and B. Gaillet, *Bull. Soc. Franc. Elect.*, Ser. 7, Vol. 6, pp. 227-253, April, 1956, in French.

Rotating Amplifier

The development of dynamo-electric or rotating amplifiers has long proceeded from single-stage machines, such as the original rototrol and the regulex (working with unstable excitation) to two-stage types, e.g., the two-stage rototrol, the amplidyne, magnavolt, etc. A further step in this development is the rapidyne, which is based on the idea of overcoming certain disadvantages and limitations of the single-stator and single-armature types enumerated by separating the two stages and using deliberately two cascade-connected d.c. generators on a common shaft one of which acts as exciter of the other.

The principles of the design of an amplifying machine are basically different from those of the design of a generator, which are dictated by the requirement of a

certain output; in the case of the amplifier the output is not the only, or overriding, consideration, but high amplification factor and small time constant are equally important; it is convenient to use their quotient as a quality criterion of an amplifier. The comparison of amplidyne and rapidyne, based on these characteristics, shows a considerable improvement achieved by the latter construction, viz., the output increased by a factor 1.8 and the quality factor improved nearly in the same ratio (1.7). Apart from this, the regulation characteristics are much better, mainly owing to the much greater initial independence of output and control circuits, reduced brush drop, etc. The difference in bulk of the two machine types, as well as in cost, is not significant.—"The Rapidyne, a Modern Rotating Amplifier." F. Nechleba, *E.T.Z.* (A), Vol. 77, No. 11, pp. 326-329, 1st June, 1956, in German.

Impulse Current Measurement

The great value of surge tests on h.v. equipment is ever more widely recognised nowadays and the technique of these measurements is well developed. This, however, does not necessarily mean that final and optimum solutions have been found for every problem involved not only in the testing and recording circuits proper, but also where their interconnection is concerned, since the latter is of a decisive importance for the faithful reproduction of the phenomena observed.

Current transformers introduce capacitive and inductive reactances which are negligible at commercial frequencies, but far from it at high frequencies, and special h.f. current transformers can be rendered distortion-free only for relatively narrow frequency-bands. Normal resistive shunts may cause fairly bad distortions both of amplitude and phase, but solenoid-type shunts may result in a relatively satisfactory compensation of the inductances in the measuring circuit.

Still better, as the author is able to prove, is a coaxial shunt of his own design. The error due to parasitic inductances is completely eliminated by it and the temperature error (for 80 deg C temperature rise) remains below 1 per cent. The error due to parasitic capacitances may be completely eliminated by screening the shunt, otherwise it is 1 per cent as a maximum, the Kelvin effect also causing an error of this order, but only at the extreme of the usual frequency range (about 1 Mc/s). The total error will, however, never exceed 2 per cent, and in the middle of the usual frequency range remain below 1 per cent.—"Coaxial Shunt for the Measurement of Impulse Currents," C. Gary, *R.G.E.*, Vol. 65, No. 5, pp. 279-289, May, 1956, in French.

Russian 400 kV Transmission

Despite the fact that the necessity for raising the transmission voltage of long-distance transmissions of high capacity to 380-400 kV was recognised years ago, preliminary investigations, planning and actual erection took in most cases, particularly in the countries affected by World War II, so long that not more than one full-scale 400 kV system is yet in actual operation.

The U.S.S.R. has the best chance to be the second country to take such a system into service, since both the Kuibyshev-Moscow and Stalingrad-Moscow systems are nearing completion. Numerous publications have already covered the outlines of these two big developments and also reported results of the preliminary experiments. The present paper, whilst less ambitious in its aims, conveys a more lively impression of the progress of the erection work and fills in very essential details of the conductor materials and arrangements, types of masts used, examples of machinery and gear used in mast erection, excavation and foundation work actually carried out. Part of the equipment comes in for criticism and necessary improvements are suggested.—"400 kV Transmission Lines in the U.S.S.R.," S. S. Rokotyan and V. N. Sergeev, *Elekt. Stantsii*, No. 2, pp. 31-36, 1955, in Russian.

Short-Circuit Characteristics

That the breaking capacity of an h.v. circuit-breaker is no independent or absolute quantity, but depends essentially on the frequency of the restriking transient and the amplitude factor of the recovery voltage after the clearance of a short circuit is common knowledge among power engineers. Since, on the other hand, the restriking frequency depends on the natural frequency of the system configuration with which the circuit-breaker is presented, it will be clear that ultimately the breaking capacity of any breaker can only be defined for a certain point of erection for which it is theoretically possible to determine short-circuit MVA, natural frequency and amplitude factor of the recovery voltage.

However, this determination is a difficult problem and different authors have tried to solve it in different ways, the most promising and nowadays fashionable method being the statistical approach supplemented by determinations on network analysers. On the other hand, many engineers will fully sympathise with the author in feeling that it must be possible to solve the problem analytically, at least in a rough approximation, to convince oneself of the correctness of the many experimental and statistical results published. This is what the author actually does and, it must be acknowledged, with the skill and elegance befitting a long-acknowledged authority in this field.—"Short-Circuit MVA, Restriking Transient Frequency and Amplitude Factor," J. Biermanns, *E.T.Z.(A)*, Vol. 77, No. 13, pp. 435-441, 1st July, 1956, in German.

Field Modelling

Three-dimensional field problems are of great importance in many branches of modern engineering, such as electron optics, h.f. heating, h.v. insulator (bushing) and transformer construction, to give only a few examples. Whilst the formal theoretical treatment of such problems is well established, this has, unfortunately, not to be taken to mean that the solutions of the well-known differential equations of these problems can be written down and evaluated in any except the simplest cases. Experimental, and particularly modelling, methods must be resorted to even in cases where analytical solutions can be given, simply because the evaluation becomes too complicated and laborious. The technique and theory of modelling, in which the electrolytic tank plays a very important part, has progressed enormously in recent years, although there is still room for improvements and special "tricks of the trade".

Even the electrolytic tank or other modelling arrangement cannot answer every relevant question unless it is set in the appropriate form. A powerful aid in this respect is the method of conformal transformations and the related principle of duality. This refers particularly to the important analogy between plane-parallel and plane-meridional fields which enables a "universal" model to be built, on which plane-parallel fields can be experimentally "checked" on the simpler plane-meridional fields with an identical configuration of the boundary regions.—"Use of the Method of Conformal Transformations for Modelling Three-Dimensional Potential and Vortex Fields," P. M. Egorov, *Elektrichestvo*, No. 5, pp. 31-38, 1956, in Russian.

Remote Indication of Field Current

New Methods for Use with Large Generators

By W. J. CARFRAE, B.Sc.(Eng.), M.I.E.E., A.M.Amer.I.E.E.*

IN modern power stations it is now common practice to place the control room at some distance from the main engine room containing the generators. In extreme cases the control room may be situated in an entirely separate building remote from the machines with which it is concerned. In any event, a power station containing a large number of generators will involve a fair length of cable run from at least some of the generators to the central control point.

Wherever the control room is situated, it is, of course, essential that the operating engineers should be given a clear and accurate indication of machine conditions. This is no serious problem with a.c. indicating instruments, connected as they are to current transformers of adequate output and accuracy, nor with d.c. voltmeters which are supplied from a relatively high voltage source. Difficulty does, however, arise with the accurate indication over long distances of generator field current, which is normally in the range of 300 to 3,000 A d.c.

Hitherto heavy-current shunts, directly connected into the alternator field circuit, have been used for measuring the current. Obviously, for economic reasons, it is necessary to restrict the heavy-current cabling between the exciter and generator to the shortest possible length. This means that the shunt must be situated somewhere in the region of the generator or the exciter, and that the light-gauge leads from the shunt to the indicating instrument in the control room will be of considerable length.

It is not difficult to appreciate that substantial errors may occur in the indication given by the instrument arising from variations in the ambient temperature of the leads connecting the shunts to the indicating instruments. Furthermore, in view of the necessarily low voltage drop across the shunt the readings are particularly susceptible to variations resulting from defects in the instrument circuit.

"D.C. Current Transformers"

A new introduction is the use of transductors for the metering of field currents. These versatile instruments have many fields of application and are known by a number of names. When used for d.c. metering the most descriptive term for them is "d.c. current transformers."

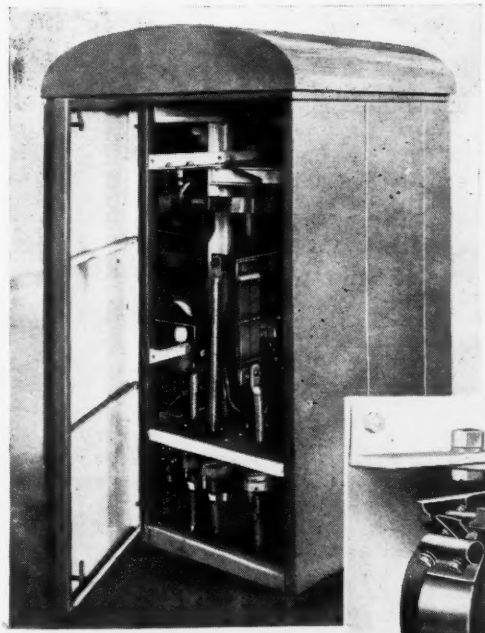
A d.c. current transformer consists essentially of a magnetic circuit embraced by two separate windings. One winding is in series with the circuit carrying the d.c. current which is to be measured. The other winding is connected across any convenient low-voltage a.c. supply, e.g. 110 or 240 V. It is in this a.c. circuit that the meter is connected, and the current in it is always proportional to the current flowing in the other winding for the following reasons:

The d.c. winding is connected in series with a highly inductive circuit, i.e. the generator rotor, which effectively prevents any rapid change of direct current, and this latter can therefore be regarded as constant when considering the principles of operation of the d.c. current transformer.

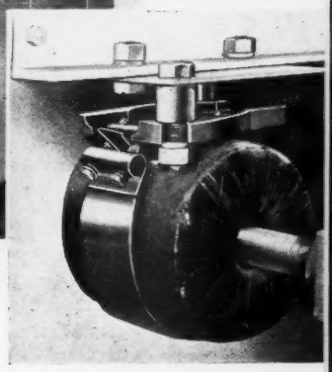
The effect produced by any current in the secondary a.c. winding is alternately to buck and boost the magnetomotive force produced by the steady direct current. As the magnetic core of the transductor is highly saturated by the passage of the direct current alone, any additional magnetomotive force due to any instantaneous flow of current in the a.c. winding in the same sense will produce negligible additional flux and, therefore, no back e.m.f. If, therefore, additional steps were not taken as described below there would be no limit to the value of current flowing in the a.c. winding in the alternate half cycles concerned.

During the intervening half cycles, however, the current in the a.c. winding produces a magnetomotive force in the opposite sense to that produced by the d.c. winding. As the magnetic circuit is initially saturated by the direct current, the initial impedance offered to the alternating current is very low, and the value rises very steeply until the magnetomotive force is equal and opposite to that produced by the d.c. winding. At this point the core becomes demagnetised, a rapid flux change occurs, and a high back e.m.f. is induced, thus limiting any further increase of current in the a.c. winding. The effect is, therefore, to produce a square wave of alternating current whose value is limited to that laid down by the value of direct current flowing in the primary winding at the time.

It remains, therefore, to cut out the alternate half cycles



Transductor fitted in field suppression cubicle



Close up view of transductor

* Manager, Turbo-Generator Engineering Department, British Thomson-Houston Co., Ltd.

when the a.c. is not metered by the d.c. The usual solution is to connect two single-phase units in series opposition so that the a.c. current flow is restricted to the correct value in every half-cycle by one or other of the two units, while the other unit is idling (see diagram). By this means an alternating current of substantially rectangular waveform, having a peak value proportional to the direct current flowing in the primary winding, is produced

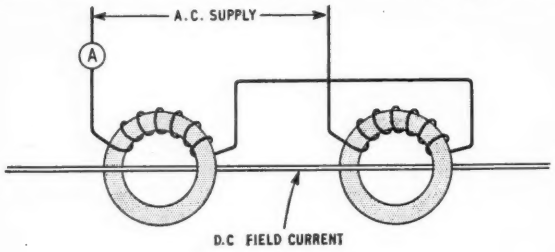


Diagram of connections

and this can be measured either on an alternating current type of instrument, or if preferred a rectifier type of instrument may be used.

The two transductor units can be of any shape, i.e. wound on ring cores or rectangular cores, and they can be two separate physical units or combined by using a three-leg core, the principle in every case remaining unchanged. Usually the d.c. winding is a single turn, i.e. it becomes a bar-primary.

The accuracy obtained depends largely on the magnetic characteristic of the core material; high accuracy—as in the case of a.c. current transformers—necessitates high permeability special alloys. Ratio error in the case of field current measurement is usually specified as not to exceed 1 per cent, but better accuracy can be obtained if necessary. The error within wide limits is independent of burden, as the impedance offered by the a.c. winding swamps any other impedance in the circuit, and accuracy is maintained for a wide metering range, e.g. 25 per cent to 125 per cent of rated current.

Another valuable property of this arrangement is that it is not affected either by variation in impressed voltage and/or frequency. A consistent reading is therefore obtained which is not liable to drift due to temperature variations or any of the other troubles which are known to affect the conventional shunt and millivoltmeter arrangement for the measurement of direct current. The normal precautions applicable to conventional current transformers, e.g. centring of bar-primaries, proximity of return conductors, etc., should, of course, be observed.

A further advantage of the arrangement described is that the exciter circuit, which is a high power circuit subject occasionally to high transient voltages is left completely insulated from the instrument circuits, which are inherently vulnerable to faults of this type. The danger of heavy short circuits in the control room is therefore avoided and risk to personnel reduced.

The secondary current can either be measured directly by an a.c. type of ammeter, or a rectifier can be included to permit the use of a d.c. moving coil instrument. With either arrangement additional instruments can be incorporated readily without affecting the accuracy of the indication. For installations of the type described above it is thought that the simpler arrangement using an a.c. ammeter is preferable, as the normal range of field current can be arranged on the open part of the ammeter scale. The equipment must of course be designed to suit the particular arrangement adopted.

The scheme described above has been in commercial service for the last three years at a large British power station with excellent results. Acknowledgment is due to the Central Electricity Authority for permission to use the photographs.

COMMUNICATIONS DEVELOPMENT

A NEW technique of communications in which the trails of minute meteors are used to "bounce" radio messages round the curvature of the earth has been developed by the Canadian Defence Research Board under the code name "Janet." Millions of meteors no larger than grains of sand enter the atmosphere of the earth every hour. Each one, as it flashes through, leaves a long trail of ionised particles about 60 miles up. The new technique uses these trails to reflect the v.h.f. radio waves over long distances. Experiments show that signals can be transmitted by this method up to 1,000 miles.

The equipment used is relatively simple. Each circuit employs two ground stations incorporating a transmitter and receiver and carefully aligned aerials, the transmitters being supplied by Redifon, Ltd. The transmitters and receivers are on continuously, but no messages are passed until a meteor hits the right spot in the atmosphere. The two receivers immediately sense the "opening" of the radio circuit and automatically switch on devices which feed messages to their respective transmitter at very high speed.

Because each trail can only be used for periods varying from milli-seconds to a few seconds, the messages have to be recorded and stored before transmission, then sent in short, fast bursts. The exceptionally high speed of the transmissions, coupled with the fact that hundreds of usable ionised trails are formed every hour between any two fixed points, permits the passing of many messages in a relatively short time. The "Janet" system has been developed to provide an economical alternative to the ionospheric scatter system and it appears to be largely unaffected by electrical and cosmic disturbances. Furthermore, the spasmodic and limited nature of the reflecting medium ensures a high degree of privacy.

As relatively low power can be used substantial savings should be shown in the costs of stations. The aerial system also appears to be much simpler. As the system operates in the 30-60 Mc/s band this will bring relief to the overcrowded conventional h.f. band. It is a little early to predict the number of new channels which will be made available but this will certainly be considerable, particularly as the system occupies a narrow bandwidth.

Design Congress

THE Council of Industrial Design is organising an international Design Congress as a sequel to the successful Congress on design policy in industry as a responsibility of high level management held in 1951. The theme of the 1956 Congress will be: "The Management of Design." It aims to compare the experience of companies in Britain, the United States and Europe in the execution of their design policies. The Congress will be held in the Victoria and Albert Museum and the Royal College of Art, South Kensington, on 12th and 13th September.

Electrolytic Polishing

A Summary of Present Practice

By R. H. WARRING

FOR the preparation of metallurgical specimens for microscopic examination electrolytic polishing is now an established technique, but like mechanical polishing it has disadvantages so that the two methods are largely complementary. It is unlikely, for instance, that electropolishing will ever completely replace mechanical polishing for work on specimens.

The method of electropolishing was developed, largely, by Jacquet and his co-workers in France (*circa* 1935) and subsequently taken up on quite a large scale in America and more recently in this country. The process consists of making the sample the anode in an electrolytic cell, the electrolyte being specific for each type of metal, and removing the distorted anode surface by electrolytic action, under controlled conditions. Apart from the fact that the resulting surface has a much higher polish than previously, it is the true structure of the metal which is revealed by subsequent etching.

This overcomes one of the main disadvantages of mechanical polishing where the surface is polished with successively finer grades of abrasive paper and finished on a wheel with a very fine grade of alumina. This method is prone to distort, and thus disguise, the true structure of the surface by the spreading of the surface layers, unless extreme care is taken during the final stages of finishing. Subsequent etching then reveals not the structure of the true surface but that of the distorted surface layer.

Equally, electrolytic polishing has its own limitations in that anodic erosion may be preferential and in the case of some polyphase materials it may not be possible to maintain the selectivity of the attack within desirable limits, so that exaggerated structures result. Thus, whilst perfect polished surfaces may be obtained with metals and alloys chemically and physically homogeneous it does not follow that electropolishing will always produce such true surfaces. In the main, in fact, it is probably true to say that the materials yielding best results with the method may be classified as aluminium and aluminium alloys, copper and copper-base alloys, some cast irons, low carbon steels, titanium (and titanium-aluminium, titanium-molybdenum alloys), vanadium, molybdenum and thoriated tungsten.

In general terms, electrolytic polishing is generally superior for polishing single-phase alloys and multi-phase alloys where all the phases are in solid solution. Results with metals or alloys containing intermetallic phases are not so satisfactory due to the widely different electrochemical properties of these phases compared with the matrix.

The mechanics of electrolytic polishing is broadly as follows. The positive voltage applied to the anode (i.e., the sample) tends to make it go into solution yielding a viscous film of complex salts enveloping the anode surface. This film has a high electrical resistance and a natural tendency to build up more rapidly in regions of maximum roughness. The ultimate effect is as shown diagrammatically in Fig. 1—a film substantially "true" on the outer surface and filling all the hollows in the rough anode surface.

Thus, over the anode surface the film resistance is variable, being least at the "high" spots on the surface and greatest in the depressions. Its resistance controls the current density at any point on the anode and thus current density is greatest at the "high" spots and least in the depression areas. Thus a condition for preferential solution of the anode is established which, under ideal working conditions, will continue until the film resistance is uniform throughout, i.e., the anode surface is perfectly smooth. From that point on the rate of anode dissolution will remain constant throughout.

The specific electrolytes used in electrolytic polishing fall into one of two classes—high- and low-resistance solutions, requiring high and low voltages, respectively, for proper operation. In the former case, control of polishing is obtained by adjusting the current density, and in the latter the bath voltage. High-voltage electrolytes usually operate within the range 10 to 70 V (and occasionally up to 100 V); and low-voltage solutions up to 10 V. Corresponding current ranges are usually of the order of 0·10 A and 0·1 A, respectively. The direct current is usually smoothed to about 1 per cent, a slight ripple being held to be advantageous for some polishing.

The electrolyte must be such that it exerts a definite attack on the metal to be polished in order to yield the anodic film, but this attack must not be too severe otherwise definite, harmful chemical attack will work against the polishing action. On the other hand, the bath solution must not passivate the anode material.

Typical high-voltage solutions are based on perchloric acid diluted with organic reagents, such as acetic acid, acetic anhydride, alcohol and ether, and give best results

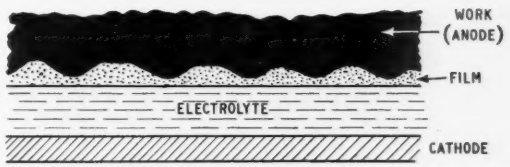


Fig. 1.—Mechanics of electropolishing

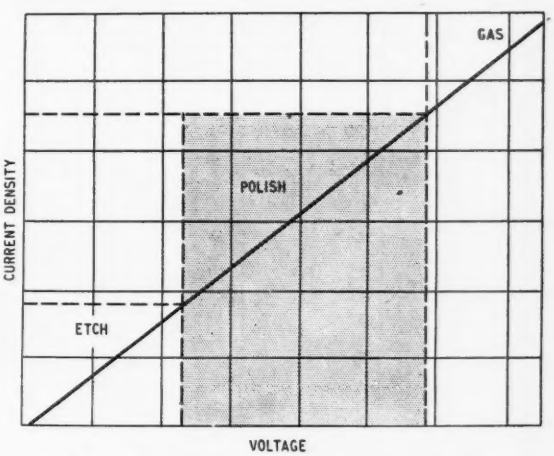


Fig. 2.—Characteristic curve for high-voltage electrolyte

with such metals as aluminium, steel, lead, tin and zinc, also nickel alloys and tin alloys. Basic solutions of this type have the great disadvantage of being explosive by nature, although more stable perchloric acid mixtures are now available.

The relative effect of the anode film resistance is small with high-voltage (high-resistance) solutions and the characteristic plot of current density against bath voltage is substantially linear (Fig. 2). Bath voltage, therefore, is adjusted to establish the reaction within the " polish " zone. With many electrolytes a stable bath voltage can only be established after a certain time, calling for progressive increments of the applied voltage until this condition is reached. The higher the resistance of the electrolyte the lower the effective current density and thus the longer the time needed for polishing.

Low-voltage (low-resistance) electrolytes are rather more flexible in application and are commonly based on phosphoric acid, with or without added organic reagents. Other acid solutions are also used, usually with alcohol additive, and have the advantage of being simple solutions. Complex alcohol solutions are sometimes employed on chromium, stainless steel, nickel and cobalt.

The current density-voltage graph (Fig. 3) takes an entirely different form with these solutions with a marked " step." The duration of the step (in volts) is largely dependent on the metal being treated, and may vary from a fraction of a volt to several volts. The stable bath condition for polishing is established by adjusting the current density to the required level.

Polishing time is much shorter than with high-voltage solutions but the effective current density is higher and thus the heating effect is more pronounced. This may complicate the process, even necessitating cooling. Thus in the case of alcohol-acid solutions, unless these are cooled the alcohol content may evaporate and upset the balance of the electrolyte. In all cases, in fact, it is generally necessary to establish optimum practice by a series of laboratory tests, to ascertain the minimum time necessary to produce a satisfactory polished finish. Prolonged polishing will not benefit the surface beyond a certain point as secondary effects may then predominate because of local heating, etc. Polishing time is, of course, also dependent on the amount of initial preparation of the surface before treatment.

The effects of localised heating can be minimised by agitation of the electrolyte. A change in solution temperature will affect its resistance and thus modify the current density, the general result being that a rise in temperature initiates an etching reaction at the anode surface. Stirring or recirculation of the electrolyte is therefore advisable. Where pumping action is employed the incoming electrolyte is usually washed over the surface of the anode, and the solution is re-circulated for cooling. Excessive agitation or velocities may disrupt the anodic film and are to be avoided.

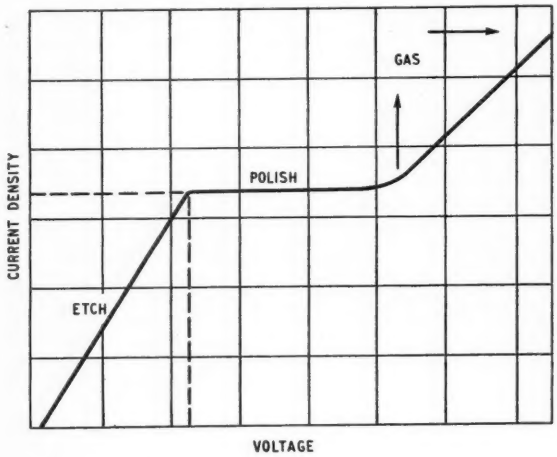


Fig. 3.—Characteristic curve for low-voltage electrolyte

Correct spacing and placing of anode and cathode is another important factor since it is essential that the current density shall be equal over the surface of the anode. Cathodes are made of different materials for the different solutions, common metals being aluminium, copper and stainless steel. Cooling coils for immersion in the bath are usually made of glass.

Undue etching of the surface may be caused by too low a current density or by overheating the bath solution, promoting direct chemical attack on the polished surface. Marked pitting of the surface is the result of too high a current density, or voltage, leading to gassing, both faults being due to operating the bath outside the polishing zone as defined by the characteristic curves.

Pitting, of course, may also occur under properly balanced bath operation because of physical defects in the surface, chemical segregation and the presence of intermetallic compounds; or in materials where there is a marked potential difference between the matrix and secondary phase, as explained earlier. It is necessary, therefore, to be able to distinguish between pitting caused by unbalanced bath conditions and that due entirely to the characteristics of the specimen itself. Nor should the possibilities be overlooked of combining both mechanical and electrolytic polishing techniques in the preparation of certain classes of specimens.

OXYGEN FOR STEELWORKS

LAST week Britain's first tonnage oxygen plant, which has been constructed by the British Oxygen Co., Ltd., at Margam, Port Talbot, South Wales, at a cost of about £1 million, was officially opened by the Home Secretary and Minister for Welsh Affairs, Major Gwilym Lloyd-George, M.P. The ceremony was unusual in that the official guests were in the board room of the British Oxygen Co. in London together with the Home Secretary who pressed a button which started up the plant in South Wales. At the same time the guests viewed the works by means of a closed circuit television link between London and South Wales.

The new plant has a capacity of about 100 tons of oxygen per day and it is to be followed very shortly by a companion plant at Margam which will have a capacity of 200 tons per day. The plant will feed the nearby works of the Steel Company of Wales through direct pipeline where the oxygen will be used for steelmaking purposes. Essentially, the oxygen is injected into the open hearth furnaces at the Abbey Works and this enables an increase in steel production of the order of 15 to 25 per cent to be made in an economical manner. The capital cost of the tonnage oxygen plant with its ancillaries is about £10 for every ton per year of oxygen. The capital cost of an open hearth steel plant is also about £10 for each ton per year of steel products. Thus an annual output of steel of, say, 100 tons can be increased to 110 tons by the employment of 1 ton of oxygen at a capital cost of £10. This compares with the £100 that would be required to get the same increase in output by extension of open hearth capacity in the traditional way.

PARLIAMENTARY REPORT

IN the House of Lords, Lord Lucas of Chilworth asked the Government if, in the interests of the national economy, they would instruct the Central Electricity Authority to suspend further operations upon the erection of the 275 kV supergrid and ask the Minister of Housing and Local Government to hold a public inquiry into the overall national amenity aspect of this project. He said the scheme envisaged a system of about 1,200 miles of cable with three-tier pylons about 136ft high, some going up to 160ft, situated 880 yd apart. Coupled with this would be twenty-two switching and transforming stations. This supergrid would be erected with the idea that it might go up to 380 kV. The largest known voltage to be carried overground in an electricity grid of this description was 500 kV which expert opinion would agree was totally unsuitable for this country owing to the electrical and atmospheric conditions. He thought that 380 kV was doubtful, and 275 kV might prove not as efficient as perhaps theory would lead us to believe.

The cost of this scheme would be somewhere in the region of £30,000 per mile, which would work out at £36 million, leaving out the cost of the twenty-two substations. In view of the shortage of steel and the need to export electrical equipment, the big expenditure authorised for improving rail facilities for transporting coal, and the building of nuclear stations, he asked the Government to re-examine the whole project.

Advantages of Supergrid

Lord Hurcomb said the transmission of electricity at a high voltage was an immense economic gain. There could be no case for re-examining the advantages of the supergrid. When he was chairman of the Electricity Commission it was accepted that to put high-voltage lines underground would not only be extremely costly but also technically open to many objections. It would involve the construction of numerous structures along the route, which would have given rise to protests on the grounds of amenity. The higher and bigger the tower or pylon, the less open to æsthetic objection it became. A pylon could be of great artistic quality, and if exact placing of the towers was properly considered and places of special interest or beauty were avoided, a line of cables stretching across the country did not give any æsthetic offence. But there might be cases where even the high-voltage lines ought to be put underground, and there were a great many cases where underground cables would avoid a great deal of unpleasant interference with landscape where difficulties at present are raised. The cost of putting cables underground should be borne by all electricity users.

Lord Conesford thought the machinery to ensure that questions of amenity were fully considered was inadequate. Were any further public inquiries to be held, and by whom? The people who objected to the new nuclear power station at Bradwell because of its effect on the scenery had been disturbed because the inquiry was conducted by an inspector appointed by the Ministry of Fuel and Power who was concerned only with the technical considerations.

Lord Munster, Minister without Portfolio, said that as far back as February, 1954, the B.E.A. gave an account in its publication "Power and Prosperity" of the proposed supergrid and its relation to the existing grid system. A new grid system had to be built to carry the additional load and as an increase in the voltage enabled more power to be transmitted with no greater current loss the Authority decided to construct on the basis of the existing system a supergrid operating at 275 kV. Certain sections were designed to operate at 380 kV. The supergrid would make good the deficiency in interconnection capacity between the existing grid control areas and so save capital investment by reducing the spare plant required. Considerable savings in fuel costs would be obtained by siting power stations near the coalfields and transmitting power in bulk to points where it would be fed into the old grid and distributed in the usual way. As the supergrid circuits had about six times the capacity of the standard circuit, fewer circuits would be required, with a corresponding simplification of technical operation and with fewer towers and lines.

First Section in Commission

The first section between Newark and Sheffield was brought into commission in the summer of 1953 and up to 31st March this year a further 424 miles had been brought into use. Present plans provided for the construction of about 1,600 route miles by 1960 and further extensions would be required after that. To suspend this operation would have most serious consequences in view of the rising demand for electricity.

The law regarding public inquiries was being considered by Sir Oliver Franks' Committee, so the subject was to some extent *sub judice*. But as the law now stood both technical and amenity aspects could be covered at the public inquiries. Up to 31st March this year the C.E.A. had had to ask the Minister for compulsory powers over 22 miles of line and wayleaves for 835 miles were obtained without any difficulty. The Minister did not believe that any better system was likely to be achieved by an inquiry such as was suggested by Lord Lucas.

Replying to the question put by Lord Conesford, the Minister said that when technical and amenity questions were to be raised at a public inquiry it was usual for the inspector from the Ministry of Fuel and Power to sit with one from the Ministry of Housing and Local Government. He did not know about the Bradwell inquiry but he would have the matter investigated.

Restrictive Trade Practices

The Restrictive Trade Practices Bill was among the Bills which received the Royal Assent on 3rd August.

Mr. Simon asked the President of the Board of Trade what plans he had for the first registration of restrictive trading agreements.

Mr. Thorneycroft said that now that the Bill had received the Royal Assent he had signed the first Order (the Registration of Restrictive Trading Agreements Order, 1956) making certain classes of agreement subject to registration. It was intended to seek Parliamentary approval of the Order early in the new Session and, if this was given, the Order would come into force on 30th November next. During the three months following that date, particulars of the classes of agreement specified in the Order must be furnished to the Registrar of Restrictive Trading Agreements. The specified classes of agreement were, broadly, those which included restrictions as to prices or other terms or conditions or which involved collective discrimination. They therefore included agreements about common prices and conditions of sale, agreements about level or agreed tendering, agreements under which preferential terms were granted to certain persons or traders and agreements under which supplies of goods were confined to certain persons or traders.

Agreements of the classes in question which contained restrictions affecting exports and which did not affect supply to the home market, did not have to be registered but must, under Section 31 of the Act, be notified to the Board of Trade.

Copies of the Order would be on sale to the public on 10th August.

Kariba Loan

Mr. Russell asked the Chancellor if he would state the full extent of the commitment of the United Kingdom in the loan of £28 million made by the World Bank for the building of the Kariba Dam.

Mr. Macmillan replied that service of the loan had been guaranteed by the United Kingdom. We had also agreed to the use of up to £10 million from our sterling subscription to the Bank as part of the loan.

Mr. Russell asked if it would not have been better to obtain all the money in the Commonwealth, thus avoiding

putting the contracts out to international tender.

Mr. Macmillan said that expenditure in the United Kingdom would be at least as much as the loan of £10 million. If Mr. Russell was suggesting tied loans, that was quite a different matter. On the whole it would be to our advantage to continue with the present system.

Mr. Harold Wilson said that the course which Mr. Russell was urging upon the Government was just the one that all parties had criticised so bitterly when it was applied by the American Government against us.

Mr. Macmillan agreed, but pointed out that this was a question of weighing the advantages or disadvantages to us. It was true, of course, that the Import-Export Bank was operated on a tied basis.

Later Mr. Gresham Cooke asked the Secretary of State for the Colonies what proportion of the financing of the Kariba Dam contract was originally sought from the Colonial Development Corporation.

Mr. Lennox-Boyd replied that the Corporation sought and was given approval for a loan of £15 million.

Mr. Cooke asked whether it was within the power of the Colonial Secretary to suggest to Colonial Governments that they should apply to the Colonial Development Corporation for the full amount of finance required, so that the World Bank was not called upon.

Mr. Lennox-Boyd said that if all the finance of this or comparable schemes came from the Corporation there would be nothing available from that body for other smaller but very important schemes.

European Trade and Tariffs

Mr. Holt asked the President of the Board of Trade, in view of the setting up of the two O.E.E.C. study groups on European trade and tariffs, whether he would set up within his Department complementary study groups to prepare definite proposals for submission to the O.E.E.C. so that the Government might give a lead in the move towards a reduction of tariffs in Europe.

Mr. Thorneycroft said that all necessary work had been and would continue to be undertaken within his Department to enable the Government to participate fully in this branch of activity of the O.E.E.C.

Mr. Bottomley asked when the Government proposed to implement the changes in the United Kingdom tariff agreed upon at the recent General Agreement on Tariffs and Trade Conference at Geneva.

Mr. Thorneycroft said the Government would lay the necessary Statutory Orders in October.

The Barnes Accident

The Minister of Transport (Mr. Watkinson), replying to Mr. Gresham Cooke, said that as was stated in the report of the Chief Inspecting Officer of Railways on the accident at Barnes on 2nd December, 1955, the complete modernisation of the power supply arrangements in the London area of the Southern Region's third rail electric system was actively in hand, and should be completed by the end of 1957.

Mr. Gresham Cooke also asked when it was hoped to establish modern colour light signalling and continuous track circuiting on the railway between Clapham Junction and Richmond as recommended in the Chief Inspecting Officer's report on the Barnes railway accident.

Mr. Watkinson said he was informed by the British Transport Commission that the completion of this work was planned for the end of 1958.

Effect of Automation

Mr. Ellis Smith asked the Minister of Labour if he would now make a full statement on the results of his consideration of automation and on the results of raising the matter at the Government Advisory Council and several joint committees.

Mr. Robert Carr, Parliamentary Secretary, said the question of automation was considered by the National Joint Advisory Council on 25th July. They were in general agreement with the conclusions of the report by the Department of Scientific and Industrial Research that automation had not so far caused any serious employment problems and was unlikely to create unmanageable problems in the future. The three sides of the Council were continuing their examination of the problems involved and the Council would resume discussion at a later meeting.

The President of the Board of Trade had also discussed the question with the Engineering Advisory Council on 4th July. Members from both sides of industry welcomed a proposal to make inquiries, which were being put in hand, about the adoption of new production techniques and the availability of special equipment. Similar discussions had taken place with other advisory bodies.

Exports to China

Viscount Elibank asked whether the Government was aware that manufacturers applying for licences to export electric motors, cables and similar equipment to China under the exceptions procedure were requested to furnish information regarding the destination and end-use of the products. This delaying practice was not helpful to British industrialists in opening out new overseas markets and placed them at a serious disadvantage.

Lord Mancroft, Under Secretary, Home Office, said that to justify the agreement which the Government had made, with other powers, for allowing exceptions to the embargo on exports to China, they must make sure that the goods to be exported were for civilian and not military use. Other Governments who were members of the Co-ordinating Committee had the same obligation. Applications for licences under the exceptions procedure were considered on their merits and the licensing authorities did not automatically call for further information, especially when the intended use was apparent from the specifications furnished.

Viscount Elibank asked how many applications had been refused because information about the use of goods or their ultimate destination had not been forthcoming.

Lord Mancroft said that in some cases the use to which the exports were to be put was self-evident; in other cases the exporters usually supplied the required information as a matter of course. The Board of Trade were anxious to keep down the period of delay to a minimum in the interests of those who wanted to export to China.

Nuclear Electricity Programme

Mr. Callaghan asked the Minister of Fuel and Power it he would review the programme of the Atomic Energy Authority with a view to accelerating the contribution that it could make to Britain's fuel requirements.

Mr. Aubrey Jones replied that he attached the highest importance to expanding and accelerating the programme as much as they practically could. He had no doubt that they would be able to achieve more than was at first thought possible, but exactly how much more could not be determined until the plans for the first stations, which were due to be submitted this autumn, had been examined.

Anglo-Russian Trade

In reply to questions by Mr. Hunter and Mr. Davies, the President of the Board of Trade (Mr. Thorneycroft) said that both the Government and British industry had welcomed the visit to this country of Mr. Malyshev, whose object was to find out what United Kingdom industry had to offer in the light of the Soviet purchasing programme submitted last April and to seek clarification about the coverage of the strategic controls.

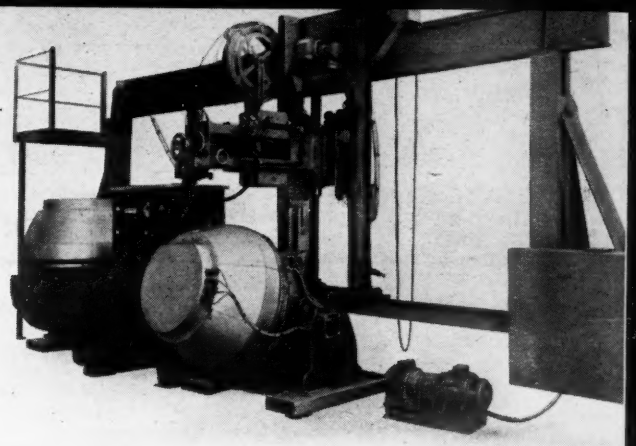
There was a large area of trade which was free from the controls. It is too soon to expect orders to have been placed, but he was confident that the visits to factories which the Government had arranged would be most useful, and he looked forward to an increase in trade between the two countries.

Power from the Sun

In reply to Mr. Ellis Smith, Mr. David Renton said that there was little prospect of obtaining power from the sun on a useful scale in this country because there was not enough sunshine. American scientists had recently discovered a means of using sunlight to convert water into hydrogen and oxygen gases but its development presented many difficult problems.

Resurfacing Coal Pulverising Mill Rolls

Technique Using Automatic Welding



Automatic welding equipment for resurfacing pulverising mill rolls

POWER stations in this country use pulverised coal as their raw material and one of the problems engaging the attention of the C.E.A. engineers is the satisfactory maintenance of roll surfaces in the pulverising mills. Considerable experimental work has been done in co-operation with various manufacturers.

An economical solution giving satisfaction has been the Metrovick automatic welding plant installed experimentally at the South Eastern Divisional Workshops, Croydon "B" power station. This has been in operation since September, 1954, and at the present time is being prepared for trials with submerged arc welding. Judging from experiments carried out, this should give even better results than those achieved so far.

In 1948 rolls were being rebuilt by hand welding as many as five or six times before they were finally scrapped. One of the major failings was that cracks, generally parallel to the axis, tended to open up each time the roll was rebuilt, and these penetrated into the base metal below. This caused chips to break away from the roll face during operation. Consequently, apparent wear was more rapid, resulting in a shorter life before the mill had to be shut down and the rolls replaced; 2,000 hours' running was the figure aimed at for rebuilt rolls. If cracking in the roll face could be prevented the number of times the roll could be rebuilt would be infinite, and the life of the rebuilt surface would probably be longer.

New rolls at this time were costing between £52 and £72 and rebuilding by hand welding £25 to £30, depending upon the amount of wear or build-up being done. It was estimated that automatic welding would cost £20 per roll. Moreover, hand welding was taking 122 hours to deposit 120 lb of metal and the operator was affected by the heat rising from the preheated roll. An automatic welding machine, of course, is unaffected by this and on experimental test a deposit rate of 140 lb in 16 hours was achieved, thus reducing the time factor to approximately one-ninth.

Inside of oven with tubular sheathed heating elements, and mill roll mounted on table

A further consideration was that after investigation and experiment on the steel, it was found necessary to preheat to 400 deg C, in order to prevent cracking, and with this heat rising from the roll face it would be practically impossible for a hand welder to work.

A pair of rolls taken out of service were experimentally welded on an automatic machine at the Metrovick works in 1949, and when returned to service were entirely satisfactory in giving the wearing life of 2,000 hours required of them.

On the basis of the success of these experiments a machine, designed and built by Metrovick, was ordered by the C.E.A. and put into service in 1954. The main features of the machine are that it is fully automatic in operation with automatic temperature control throughout the whole period of preheat, weld and post-heat.

The complete machine is shown in the above illustration. One jig is tilted in the weld position and the other is horizontal in the loading position. The main control panel stands centrally between them and the electronic control panel is mounted on the right-hand side frame. The small m.g. set supplies a low voltage d.c. for the arc control circuit.

The welding jigs comprise a tilting table holding the mill roll, which is rotated at welding speed by a variable motor drive. The jig rotating motor and the head projecting slide motor are electronically controlled and locked together so that as the work rotates a continuous spiral weld deposit is made on the mill roll face. A stationary head is necessary on the build-up at the ends of the roll, and for filling in cavities in the worn roll face, and the drive clutch is thrown into the disengaged position for these runs.

The second illustration shows the inside of one oven dismantled from the table and a mill roll mounted on the table. The oven temperature is automatically controlled during preheat, welding and post-heat periods. The temperature programme controller is arranged to switch on the heaters automatically for preheating and to switch them off at the end of the post-heat period. Temperature limit control is effected by thermo-couples mounted on spring loaded arms bearing on the inside machined surface of the mill roll. The oven is heated by three banks of standard Metrovick tubular sheathed elements totalling 16 kW.

The machine has now been in operation for nearly two years and the present day cost of resurfacing is very little above that which was estimated seven years ago. The average life of a resurfaced roll has now reached 2,500 hours and the present target is 5,000 hours.

Various alternative methods of building up the roll face have been suggested and some tried. The most promising is the submerged arc welding process depositing a high chromium deposit. The cost of wire and flux, however, is about twice the cost of the Metromatic P350 electrode.

NEW ELECTRICAL EQUIPMENT

Adjustable Platforms

ANDERSTON CLYDE ENGINEERS, LTD., 45-47, Pitt Street, Glasgow, announce a new range of maintenance and production platforms. A particular feature of the range is the "Spaceman" hydraulic working platform, which is extremely compact, and gives access for working purposes up to 40ft. This machine collapses to pass through normal doorways, and can easily be moved through closely packed machines on a factory floor. It can also be collapsed further to go into small lifts. Operation is by triple or quadruple hydraulic rams with a platform suitable for two men: the top hand rails are collapsible and break down for transit, and the machine complies in all respects with the Factory Acts.

Hydraulic operation is provided by a Dowty gear pump driven by a ½ h.p. electric motor, and also embodied in the reservoir is a hand pump for operation when electric current is not available. The operator is able to select whether he wishes the platform to remain fixed or rotate freely, and the new unit has the virtue of easy mobility in that one man can pull and steer even the largest model when transferring from one working position to another.

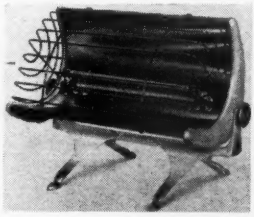
Diesel Driven Welding Generators

CHAMBERLAIN INDUSTRIES, LTD., Staffa Works, Staffa Road, Leyton, E.10, are now sole agents in this country for the Austrian-built "Jenbach" diesel driven welding generators.

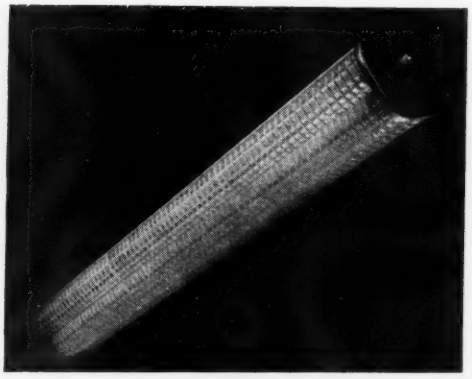
These portable welding sets have been developed for workshop use as well as for repair work away from a fixed workshop. The "JW 20 Sf" mobile generator is driven through a flexible vee-belt drive designed with a high factor of safety. The "JW 20 M" diesel engine has a horizontal working cylinder surrounded by a large water space. Working on the four-stroke cycle, the engine will run continuously at 1,500 r.p.m., giving an effective 20 h.p. at the belt pulley. The continuous output of the generator is 250 A at 30 V, the minimum current being 50 A at 15 V.

Reflector Fire

The latest electric fire to be announced by CARRON COMPANY, Carron, Falkirk, Stirlingshire, is the "Crescent," the name being derived from its crescent shaped end pieces. Small knobs, gold coloured, are provided for adjusting the chromium reflector, the whole being finished in cream and gold "Carrontine." Both 1 and 2 kW models are available and the fire measures 12¼in high by 17¼in wide by 12in deep. The weight is in the region of 10 lb. The prices are £3 16s (1 kW) and £4 17s (2 kW) plus £1 13s 4d and £2 2s 6d respectively for purchase tax in the United Kingdom.



Above: Carron "Crescent" reflector fire



Right: H. W. Field & Son's domestic fluorescent fitting

Fluorescent Fitting

A domestic fluorescent fitting designed for ceiling fixing, suspension or wall-mounting has recently been placed on the market by H. W. FIELD & SON, LTD., Harold Wood, Essex. The gear is housed within the unit and the light is diffused by a sectional polystyrene plastic louvre. The complete fitting can be mounted direct to the ceiling or suspended on chain or tubes.

There are three types in the range, a 4ft 40 W and a 3ft 30 W for general lighting purposes and a 2ft 20 W designed for halls or wall mounting. All have keyholes for easy fixing for either horizontal or vertical wall-mounting. The diffusers can be supplied in clear, yellow, gold, red or green and the fitting is finished in bronze.

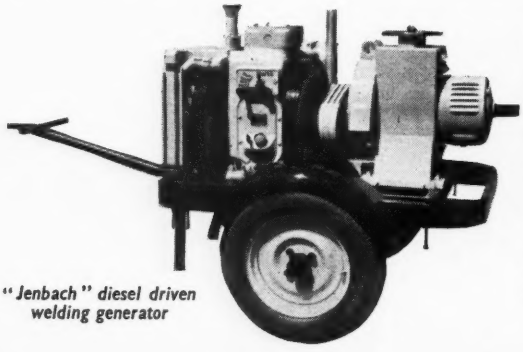
The prices, with clear diffusers, are: 4ft 40 W, £5 10s (plus 13s 11d purchase tax); 3ft 30 W, £5 3s (plus 12s 4d); and 2ft 20 W, £3 13s 6d (plus 7s 6d). With coloured diffusers the cost respectively is: £6 8s (plus 18s); £5 18s (plus 15s 9d); and £3 19s 6d (plus 8s 3d).

Outdoor Lanterns

A new range of contemporary outdoor lighting fittings has recently been introduced by FALK, STADELMANN & CO., LTD., 91, Farringdon Road, London, E.C.1. Known as the "Beaufort" fitting, the range comprises three basic types, one for post-top mounting for 200 W lamps and two corresponding types for wall-mounting for 100 and 200 W lamps respectively.

The lanterns consist of a spun aluminium hood, stove-enamelled smoke grey with a white enamel reflector. The top is supported by four aluminium tubes attached at the base to a cast aluminium alloy spigot cap. The wall-mounting lanterns are similar in appearance but have in addition a back-plate for wall attachment.

Each type is available in seven different forms without any alteration of the metalwork, except that in one instance it is necessary to drill four holes in the arms to take a glare shield. The basic form is a fitting for a bare lamp. To this same fitting "Perspex" enclosures, clear or opal, can be added, and if necessary a clear "Perspex" enclosure covering a refractor making them suitable for street lighting. The price of the fitting illustrated (S.93849E) is £9 13s.



"Jenbach" diesel driven welding generator

One of the "Beaufort" range of outdoor lanterns (Falk, Stadelmann & Co., Ltd.)

New Season's Fires and Convectors

MODERN styling is apparent in the latest additions to the range of heating appliances recently announced by the General Electric Co., Ltd., which includes three new fires and two convector heaters. First of the fires is a 2 kW two-bar pedestal mounted "Cosyglo" model of unusual shape. It has a newly designed reflector constructed to provide maximum all-round warmth over a wide area. The fire is coloured a moonstone grey and has a circular black base with yellow relief. It measures 13⅜in high by 15 3/16in wide by 9⅞in deep. The price of this fire (catalogue No. D.2815) is £4 18s 6d plus £2 3s 3d purchase tax in the United Kingdom.

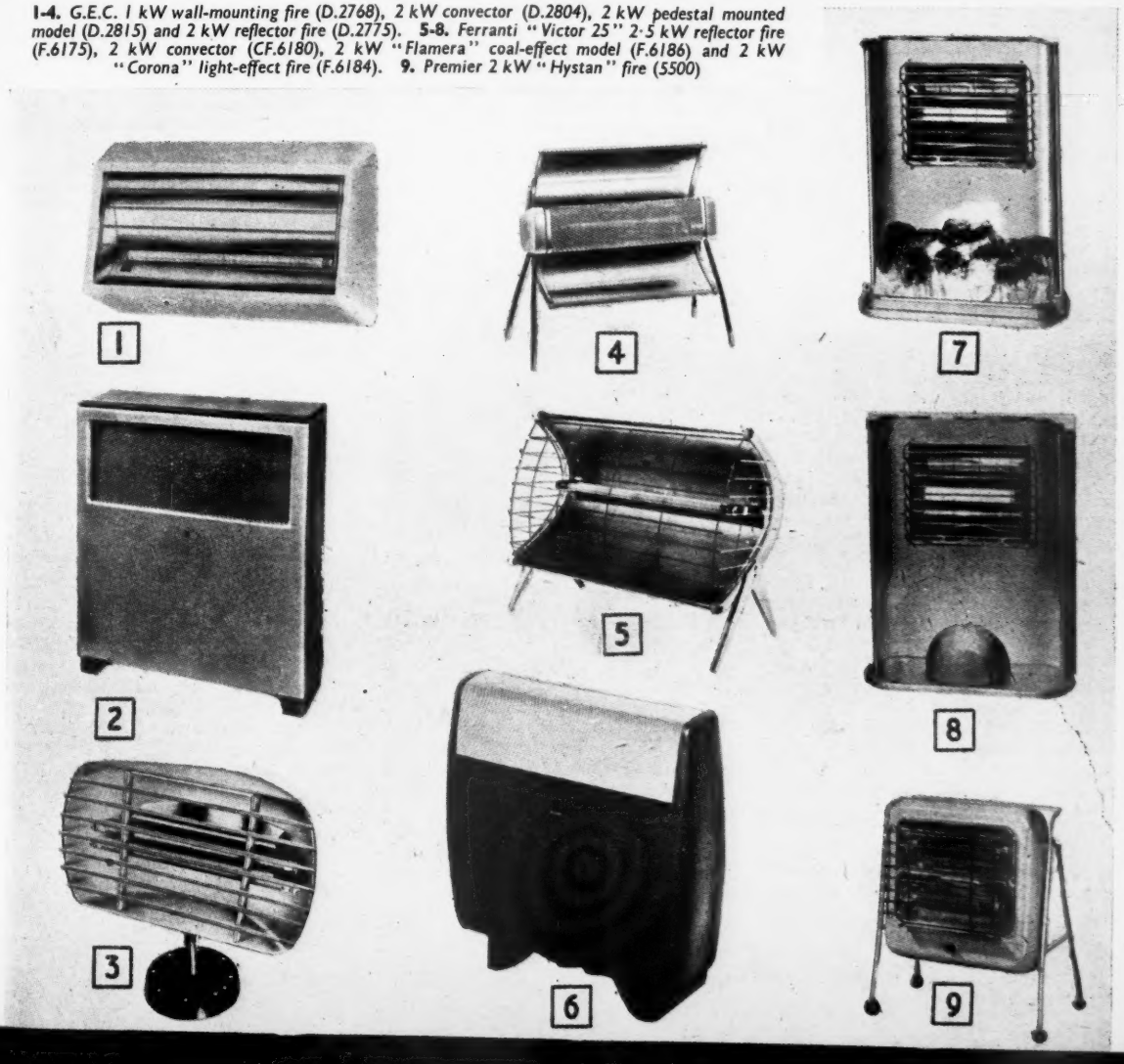
The next fire is also a 2 kW reflector model and is designed to radiate heat at the correct level for warmth and comfort. This is styled on modern lines and is finished in moonstone grey and burgundy with black legs. A honeycomb guard protects the elements. The price (D.2775) is £4 16s plus £2 2s 1d tax. The third fire is designed for use in the bathroom or nursery and is a 1 kW high level wall-mounting model. It has austere clean lines, is particularly easy to keep clean, and is finished in cream. It measures 9½in high by 15 11/16in wide by 4 3/16in deep. The price (D.2768) is £2 15s 6d plus £1 4s 4d tax.

The convector heaters in 1 and 2 kW sizes are similar in appearance, both having rectangular hammered bronze cases with dark bronze top and feet. Heat is emitted through a honeycomb metal mesh. The 2 kW model is controlled by a variable thermostat and is for use on a.c. only. The height of both models is 27in and the depth 7in. The respective width measurements are 17in and 23½in. The price of the 1 kW convector (D.2802) is £5 5s plus £2 6s 1d tax and the 2kW (D.2804) is £8 5s plus £3 12s 5d tax.

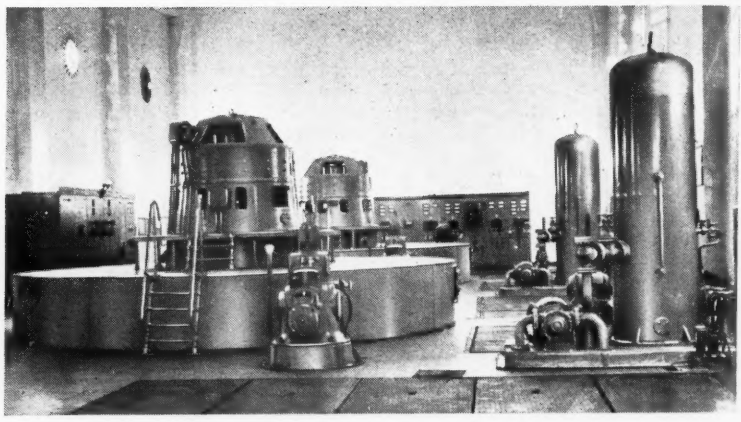
Included in the new season's range of Ferranti electric fires and convectors are three fires, including a coal-effect model and an attractively styled convector heater. The convector is a 2 kW model, thermostatically controlled, and measures 23⅞in high by 23in wide by 7¼in deep. It has a golden bronze stoved enamel hammered finish with copper fawn top grille. The price (CF.6180) is £7 6s 3d plus £3 4s 2d tax. The "Victor 25" fire is of contemporary design and is similar to the company's two existing models of this type, but of larger dimensions, measuring 13½in high by 16½in wide by 7¾in deep. The total loading is 2½ kW and the frame finish is in cream enamel with a chromium plated reflector. The price (F.6175) is £5 plus £2 3s 11d tax. The remaining two fires are of conventional design and the dimensions, 24¼in high by 20in wide by 9¼in deep, are such that they will cover the normal fireplace. Both are 2 kW models and each has a silver enamelled frame and chromium plated reflector. The "Flamera" (F.6186) has an imitation coal effect and is priced at £10 18s 3d plus £4 15s 9d tax. The "Corona" (F.6184) has a light effect in place of the imitation coal and the price is £10 7s plus £4 10s 9d tax.

Premier Electric Heaters' new "Hystan" fire has a one-piece steel body mounted on a solid rod frame. The finish is in cream with maroon moulded feet. Heating is by means of two 1 kW rod type elements, each mounted in its own polished reflector, and a switch is provided for heat control. The price (5500) is £4 15s plus £2 1s 9d tax.

1-4. *G.E.C. 1 kW wall-mounting fire (D.2768), 2 kW convector (D.2804), 2 kW pedestal mounted model (D.2815) and 2 kW reflector fire (D.2775).* **5-8.** *Ferranti "Victor 25" 2·5 kW reflector fire (F.6175), 2 kW convector (CF.6180), 2 kW "Flamera" coal-effect model (F.6186) and 2 kW "Corona" light-effect fire (F.6184).* **9.** *Premier 2 kW "Hystan" fire (5500)*



GENERATION AND DEVELOPMENT



Turbine room of the Sevan station, 100 metres underground

Increased Sales in Kent

The South Eastern Electricity Consultative Council held its quarterly meeting at Dover on 25th July and it was appropriate, therefore, that the Kent District Committee was able to report notable development in that area. Data submitted showed that sales in Kent rose by 12·8 per cent in 1955-56. In the case of the Dover District (covering Dover, Deal and the surrounding rural territory) the increase was 32·4 per cent, the highest of any district in the county. This was accounted for in part by additional supplies to domestic, commercial and farm consumers but mainly to the increased requirements of the collieries. This growing demand had necessitated an increase in the capacity of the 33 kV transmission system to the locality. In the whole of Kent 46 fewer farms were connected than in 1954-55 whereas the Dover District reported an increase of 13·6 per cent.

Referring to criticisms of delay in the change-over from d.c. to a.c. in Sheerness, the Committee stated that in view of financial restrictions it was not at present the policy of the Board to proceed with change-over work unless the d.c. mains or plant were loaded to capacity.

Rural Progress in North East

A report by the North Eastern Electricity Board on the progress of the rural electrification scheme submitted at a meeting of the Consultative Council at Newcastle-on-Tyne, stated that of the 218,300 rural premises in the area, 182,660 (84 per cent) had been supplied. Of the 1,304 villages and hamlets 1,280 were now served, leaving 24 to be dealt with under stage four of the rural development plan. There were 20,357 farms in the area capable of receiving a supply and 11,250 had been connected. The actual expenditure on rural development since vesting day was £3,581,912 and during the current year it was proposed to spend £763,000.

Regarding development generally, during the past quarter high voltage supplies had been afforded to 22 industrial and commercial consumers. Estimates amounting to £2 million for schemes covering 92 housing and 150 rural supplies had been approved.

Repairs to Electrical Appliances

Because in some cases electrical appliances are damaged through negligence, Samford R.D.C. has decided to fix a reasonable life for the various items of equipment and if repairs are necessary before the expiry of this period the tenants will be required to pay the cost.

Midlands Board Criticised

Lieut.-Col. P. W. Robinson, joint managing director of a firm of Stourport-on-Severn carpet manufacturers and who farms at Murrells End Farm, Red Marley, told the Midlands Electricity Consultative Council that in his opinion the Board should show "more drive" in taking a much needed supply of electricity to his farm. He gave a concise summary of the negotiations he had conducted with various authorities to enable him to farm at Red Marley and said that he had received full co-operation except from the Electricity Board. "I have been quite unable to get them to take any interest," he said. No official of the Board had so much as visited his farm. He thought that what was lacking was the will to serve.

The Council went into committee to discuss Col. Robinson's representations and later a spokesman said: "The Council is satisfied that the Board is doing everything possible to bring the supply to Col. Robinson's farm at the earliest possible time."

It was stated that the supply to the farm was part of a scheme which involved 900 premises, 174 farms, 53 miles of overhead line, 128 substations and 43 miles of low voltage line. It would cost £120,000.

Canadian Atomic Power Station

Work is expected to begin this month at the Ottawa River site of Canada's first atomic power plant. The annual report of Atomic Energy of Canada, Ltd., says that detailed design of the demonstration power plant is well advanced and that tenders have been called for all major components.

The plant, expected to be in operation in mid-1959, is being built jointly by the Ontario Hydro-Electric Power Commission, the Canadian General Electric and Atomic Energy of Canada, a Crown company, which operates the Chalk River, Ont., atomic project. Initial work will involve construction of the turbines and generators; work on the reactor part of the plant will not start until next year.

To be known as NPD (nuclear power demonstration), the plant will generate about 20,000 kW and will cost approximately $14·5 million. Atomic Energy of Canada will contribute $9 million, Ontario Hydro $3·5 million and Canadian General Electric $2 million.

Sevan-Razdan Power Cascade

Three of the eight hydro-electric power stations forming the Sevan-Razdan cascade are in operation on the Razdan River, flowing out of Lake Sevan, in Armenia. The others will be completed in the present five-year period. The cascade will make it possible to irrigate another 100,000 hectares of desert lands. The Sevan hydro-electric station, the first of the cascade, has been built 100 metres underground. It regulates the discharge of water from Lake Sevan.

Loan for Norwegian Scheme

Norway is to receive a loan of $25 million from the World Bank for hydro-electric power development. This will help finance the Tokke power project which will add 400,000 kW to the electricity network which serves south-eastern Norway, including the city of Oslo. This area now consumes 55 per cent of all the power produced in Norway.

The Tokke project is the first stage of what will be the largest hydro-electric development in Norway; the whole scheme involves the regulation and utilisation of the Tokke and Vinje river system, and the ultimate installation of 800,000 kW of new hydro-electric capacity.

The first 100,000 kW unit will come into operation in 1961, and the other three before the middle of 1963. All of the power will be sold in bulk to distributing authorities and to industry.

Financial Section

REPORTS and DIVIDENDS

Oldham & Son, Ltd.—The report and accounts for the year ended 31st March last, now issued, confirm the figures given in our issue of 20th July. In his accompanying statement, Mr. John Oldham (chairman and joint managing director) says that the year has been one of continued progress, although it has been a period not entirely free of difficulties in the shape of rising costs of raw materials, increased wages and other items of expenditure. These increases have been largely absorbed by improved working methods and also, to some degree, at the expense of profits. They did not attempt to pass on to customers the increased costs and their selling prices still remained at 1952 levels. Sales in all sections materially exceeded those of the previous year while the volume of production was a record. During the year a new process, "Power Seal," was introduced into the production of their "Major" type range of automobile starting batteries and also in certain special types for military and other purposes calling for batteries ready for immediate service, and the new process has been well received.

There has been an all-round increase of over 50 per cent in exports. In South and Central Africa, India, Australia and France the overseas companies continue to make a substantial contribution to the group's trading. In Australia a new building is being erected on land adjoining the existing separator factory at Artarmon, Sydney, and it is anticipated that a start will be made with the production of new components by the end of the present financial year. Extensions are also being made to the Madras premises in India.

The research and development section continues to expand. One of the most recent developments is a new type of power battery employing a new design of double sleeve plate construction, which will confer important advantages in capacity and longer life in batteries required for battery-propelled vehicles, railway and road transport, mine-lighting and mechanical handling equipment.

The Pulsometer Engineering Co., Ltd., has declared an interim dividend of 10 per cent on £560,000 ordinary capital. In announcing the dividend the directors state that in the absence of unforeseen circumstances they expect to recommend a further 10 per cent for the year. When the 5s ordinary shares were introduced on the London Stock Exchange last month the directors forecast a dividend of 17½ per cent for 1956 on the increased ordinary capital if profits were maintained at the 1955 level. For 1955 the interim dividend was 5 per cent, and was followed by a second interim dividend of 20 per cent both of which were paid on the then issued ordinary capital of £237,840.

New Companies

Berryan Electrics, Ltd.—Registered 25th July. Capital £100. Electrical engineers and contractors, manufacturers of radio apparatus, etc. Regd. office: 156, Strand, W.C.2.

Lamperdene Electrics, Ltd.—Registered 25th July. Capital £100. Other particulars are similar to Berryan Electrics, Ltd.

Electronics (Roberttown), Ltd.—Registered 25th July. Capital £2,000. Electronic, radio and television engineers, etc. Directors: D. Stead and R. Stead. Regd. office: Balme Mills, Child Lane, Roberttown, Liversedge.

Multi-Recording, Ltd.—Registered 18th June. Capital £100. Manufacturers of and dealers in electronic machinery and equipment, sound reproducing and dictating machines, multi-channel recording and electrical acoustical equipment, etc. Directors: P. W. G. Lester and F. G. Holland. Regd. office: 27, Craven Street, W.C.2.

Craven Electronics, Ltd.—Registered 25th June. Capital £10,000. Manufacturers of and dealers in electronic, electrical and scientific plant, etc. Directors: L. S. Wooler, G. F. Craven and A. H. Bell. Regd. office: 184/5, Swan Arcade, Bradford, 1.

Roy Pollard, Ltd.—Registered 27th June. Capital £2,000. Radio and television engineers, etc. Directors: S. B. Ashton, G. R. Pollard and Jean M. Pollard. Regd. office: 1756, Coventry Road, South Yardley, Birmingham.

G. C. J. Hunt & Sons, Ltd.—Registered 27th June. Capital £2,000. Electrical and general engineers, etc. G. C. J. Hunt, permanent governing director. Regd. office: Onslow Bridge Chambers, Bridge Street, Guildford, Surrey.

W. S. Burton, Ltd.—Registered 27th June. Capital £1,000. To acquire the business of electrical contractor carried on by William S. Burton at East Horsley, etc. Directors: W. S. Burton and Mrs. Blanche C. Burton. Regd. office: Station Approach, East Horsley, Surrey.

Mutual Electronics (Gt. Britain), Ltd.—Registered 26th June. Capital £1,000. Electrical and mechanical engineers, etc. Directors: R. W. McKirdy, B. S. Magill, K. P. Thompson and A. D. Smith. Regd. office: 3, Cannon Street, Accrington, Lancs.

Delaney Electronics, Ltd.—Registered 27th June. Capital £100. Manufacturing, assembling, repairing, buying, selling, importing, exporting or otherwise dealing in apparatus, plant, machinery and accessories used or capable of being used in connection with generation, accumulation, transmission, utilisation and supply of electrical energy, etc. Directors: C. T. Delaney and Yvonne K. Delaney. Regd. office: 95, Scrubs Lane, Willesden, N.W.10.

Lead-in Wires, Ltd.—Registered 28th June. Capital £300. Manufacturers of and dealers in electrical, telegraph, telephone, radio and television components and goods, etc. Directors: C. Murman and Mrs. Irene Murman (secretary). Regd. office: Balfour House, Finsbury Pavement, E.C.2.

Carter & Geere (Recorders), Ltd.—Registered 30th June. Capital £1,000. Electronic engineers, manufacturers and dealers in and repairers of electrical and radio goods, television sets, sound reproducing machines, tape recording machines, gramophones, etc. Directors: J. Geere and J. W. Carter. Regd. office: 503, Chorley Old Road, Bolton.

Baden Saville, Ltd.—Registered 29th June. Capital £10,000. Electrical engineers, general electrical installation contractors, manufacturers of and dealers in radio and television sets, etc. Directors: W. B. Saville, Mrs. May V. Saville and H. A. Knightbridge. Solicitors: F. H. Bright & Sons, Maldon, Essex.

Charn Electric Co., Ltd.—Registered 29th June. Capital £2,000. Directors: S. A. Martin, Vera Martin and J. Martin. Regd. office: Wellfield, Station Road, Hailsham, Sussex.

Alguide, Ltd.—Registered 20th June. Capital £1,000. Manufacturers of and dealers in radio, electronic, electrical and mechanical apparatus, etc. Directors: J. E. Ellis and A. D. Rhodes. Regd. office: Newby Bridge Lane, Newby, Scarborough.

Automation Equipment, Ltd.—Registered 16th June. Capital £100. Developers, designers, inventors, constructors and manufacturers of industrial processes and machinery of all kinds, manufacturers of automatic machinery, apparatus and devices, etc. N. J. Cobden signs as director. Solicitors: Aberstones, 6, Broad Street Place, E.C.2.

Increases of Capital

Electro Methods, Ltd.—Increased by £30,000 in £1 ordinary shares, beyond the registered capital of £45,000.

Sunbeam Electric, Ltd.—Increased by £350,000 in £1 shares, beyond the registered capital of £350,000.

Nash-Kelvinator, Ltd. — Increased by £500,000 in £1 ordinary shares, beyond the registered capital of £1,000,000.

Hilger & Watts, Ltd.—Increased by £185,500, in 5s ordinary shares, beyond the registered capital of £412,500.

Morley's Electrical Services (Holloway), Ltd.—Increased by £2,900, in £1 ordinary shares, beyond the registered capital of £100.

E. S. G. Sales, Ltd.—Increased by £11,000, in £1 ordinary shares, beyond the registered capital of £5,000.

Electrical & Radio Wholesalers (North Devon), Ltd.—Increased by £2,500, in 4,000 founders of 2s 6d and 2,000 ordinary shares of £1, beyond the registered capital of £4,000.

Liquidations

Harries Thermionics, Ltd., radio and electronic engineers.—Winding up voluntarily. Liquidator, Mr. G. McKee Todd, 17, Half Moon Street, London, W.1, appointed 16th July. Particulars of claims to the liquidator by 15th August.

Savoy Radio, Ltd.—Winding up voluntarily. Liquidator, Mr. N. W. Osborne, 11-12, Finsbury Square, London, E.C.2.

Qwik Electrics, Ltd., dealers in electrical goods.—Winding up voluntarily. Liquidator, Mr. W. J. Seed, 70, Norman Road, Rusholme, Manchester, 14, appointed 10th July.

Bankruptcies

K. M. Ashworth and **D. Revell,** trading in co-partnership under the style of Ashworth & Revell, at 265, Bradford Road, Frizinghall, Bradford, and at 120, Otley Road, Shipley, Yorks, as electrical contractors.—First and final dividend of 1s 9¾d in the £, payable at 36, North Parade, Bradford, 1.

K. M. Ashworth and **D. Revell,** electrical contractors (as above) (separate estate of D. Revell).—Last day for receiving proofs for dividend 13th August. Trustee, Mr. G. E. Rushton, 36, North Parade, Bradford.

T. R. Hugo, carrying on business under the style of Victor Hugo's at 51, Fawcett Road, Southsea, Hants, radio and electrical engineer.—Last day for receiving proofs for dividend 15th August. Trustee, Mr. W. H. Meredith, Official Receiver, 16, Westwood Road, Southampton.

Our Stock Exchange contributor is at present on holiday. His notes will appear again on his return.

NEW PATENTS

Electrical Specifications Recently Published

The numbers under which the specifications will be printed and abridged are given in parentheses. Copies of any specification (3s 0d each including postage) will be obtainable after 15th August from the Patent Office, 25, Southampton Buildings, London, W.C.2

1952

12263. Electric & Musical Industries, Ltd. —Circuit arrangements embodying electron-discharge devices. 14th May, 1953. (755013.)

1953

18938. Cathodeon, Ltd.—Television pick-up tubes and transmitting apparatus incorporating same. 8th July, 1954. (755015.)

18961. Reyrolle & Co., Ltd., A.—Electric switchgear. 8th July, 1954. (755016.)

27867. Siemens Bros. & Co., Ltd.—Automatic selecting systems. 1st October, 1954. (754909.)

28668. Siemens Electric Lamps & Supplies, Ltd.—Electric semi-conductor devices. 15th October, 1954. (755020.)

1954

87. General Electric Co., Ltd., and French, G. P.—Electric pulse generating apparatus. 23rd December, 1954. (755102.)

397. General Electric Co., Ltd., and Ribchester, E.—Interference limiting circuits for television receivers. 21st December, 1954. (755024.)

645. Zahnradfabrik Friedrichshafen Akt.-Ges.—Mountings for current supply brushes for slip rings. 8th January, 1954. (754933.)

1862. Pye, Ltd.—Synchronising pulse separator circuits particularly for television. 30th December, 1954. (755108.)

2241. Allis-Chalmers Manufacturing Co.—Air-blast electric circuit interrupters. 25th January, 1954. (754726.)

2321. Standard Telephones & Cables, Ltd. —Electron tube. 26th January, 1954. (754727.)

2953. Compagnie pour la Fabrication des Compteurs et Matériel d'Usines à Gaz.—Quick action telemetering systems. 1st February, 1954. (755030.)

3826. Teddington Aircraft Controls, Ltd. —Electric actuator mechanisms. 9th February, 1955. (754730.)

4260. Ges. zur Forderung der Forschung an der Eidg. Techn. Hochschule.—Electron guns for producing electron beams. 12th February, 1954. (754849.)

4946. English Electric Co., Ltd.—Tanks for oil-immersed electrical apparatus. 18th February, 1955. (754733.)

5009. General Electric Co.—Liquid-cooled stationary electrical apparatus. 19th February, 1954. (754838.)

5012. British Thomson-Houston Co., Ltd. —Electrical pulse generating circuit arrangements. 18th February, 1955. (754941.)

5323. British Thomson-Houston Co., Ltd. —Mounting of large machines on a bed or seating surface. 23rd February, 1955. (754943.)

5690. Midland Electric Manufacturing Co., Ltd.—Electric switches suitable for multi-phase circuit control. 24th February, 1955. (755124.)

6010. Marconi's Wireless Telegraph Co., Ltd.—Radar systems. 1st February, 1955. (754736.)

7096. Hamilton, J.—Electrical cooking pot or vessel. 10th March, 1955. (755128.)

7393. Telefunken Ges.—Frequency changing mixing circuits. 15th March, 1954. (754853.)

7470. British Thomson-Houston Co., Ltd. —Manually operated control devices for radar and like equipment. 22nd March, 1955. (754846.)

8150. Automatic Electric Laboratories Inc. —Selecting system utilising rotary switches. 19th March, 1954. (754855.)

8682. Electric & Musical Industries, Ltd. —Colour television transmitting systems. 15th March, 1955. (754742.)

8924. Standard Telephones & Cables, Ltd. —Arrangements for coupling a coaxial transmission line to a helix slow wave structure. 26th March, 1954. (754861.)

10515. Machlett Laboratories, Inc.—High voltage electron tubes. 9th April, 1954. (754748.)

10805. Tokyo Shibaura Electric Co., Ltd. —Microwave amplifiers and microwave radio relay apparatus. 13th April, 1954. (754750.)

11045. Edison Swan Electric Co., Ltd.—Marking of wires and the like for identification. 14th April, 1954. (755039.)

11054. Hughes Aircraft Co.—Electronic camera tube. 14th April, 1954. (754752.)

11216. Hoover, Ltd.—Apparatus for testing windings. 15th April, 1954. (754865.)

11282. Automatic Telephone & Electric Co., Ltd.—Telephone systems. 10th February, 1955. (754962.)

11796. English Electric Co., Ltd.—Dash-pot type damping devices. 22nd April, 1955. (755136.)

12237. Oldham & Son, Ltd., and Booth, F. —Separators for electrical storage batteries. 3rd March, 1955. (754755.)

12386. Soc. Francaise Radio-Eléctrique.—Electric pulse code modulation systems. 28th April, 1954. (754758.)

12605. Philips Electrical Industries, Ltd.—Transistor amplifiers with gain control. 30th April, 1954. (754759.)

14234. British Thomson-Houston Co., Ltd. —A.c. dynamo-electric machines. 6th May, 1955. (754769.)

14755. Compagnie Générale de Télégraphie sans Fil.—Electrode systems for oscillator tubes having crossed fields. 19th May, 1954. (755145.)

16597. Communications Patents, Ltd.—Electric motor control apparatus suitable for calculating systems. 4th June, 1954. (755051.)

16992. Etablissements E. Jaeger.—Electronic frequency dividing apparatus. 9th June, 1954. (754971.)

17139. Vitarama Corporation. — Closed link electronic cameras. 10th June, 1954. (754882.)

17425. General Electric Co.—Electrical time switches. 14th June, 1954. (754972.)

18165. British Thomson-Houston Co., Ltd. —Light projection devices. 21st June, 1954. (755155.)

18400. English Electric Co., Ltd.—Dynamo-electric machines. 17th June, 1955. (754781.)

19156. Liquidometer Corporation.—Securing an electric plug and socket connector fitting to a coaxial cable. 30th June, 1954. (755159.)

20750. Standard Telephones & Cables, Ltd.—Circuit arrangement for coupling pulse sources to variable loads. 16th July, 1954. (755064.)

21282. General Electric Co.—Thermostats for controlling electric flat-irons. 21st July, 1954. (754793.)

21320. Radio Corporation of America.—Magnetic core memory system. 21st July, 1954. (754891.)

21641. Sulzer Frères Soc. Anon.—Forced flow steam generators operating at supercritical pressure. 23rd July, 1954. (755164.)

22204.—Rumianca Soc. Per Azioni.—Electric furnace for the manufacture of carbon sulphide. 29th July, 1954. (754794.)

22496. Philips Electrical Industries, Ltd. —Direct-voltage electronic amplifiers. 3rd August, 1954. (755072.)

23080. Schrack Elektrizitats-Akt.-Ges., E. —Electromagnetic switch for d.c. or a.c. particularly relay, contactor, overload switch or the like. 9th August, 1954. (754797.)

23589. Western Electric Co., Inc.—Coupling arrangements for electromagnetic wave energy transmission systems. 13th August, 1954. (755174.)

25808. Philips Electrical Industries, Ltd.—Magnetic cores for use with magnetic trigger systems. 6th September, 1954. (754801.)

26296. Pertrix-Union Ges.—Galvanic pile batteries. 10th September, 1954. (755179.)

26338. Marconi's Wireless Telegraph Co., Ltd.—Adjustable waveguide circuits. 10th September, 1954. (754802.)

27658. Philips Electrical Industries, Ltd. —Circuits comprising two gas and/or vapour filled electric-discharge tubes. 24th September, 1954. (754993.)

27667. Standard Telephones & Cables, Ltd.—Method of manufacturing selenium rectifiers. 24th September, 1954. (755085.)

27680. Siemens & Halske Akt.-Ges.—Apparatus for the time-displacement of electrical impulses. 24th September, 1954. (754908.)

28392. Sulzer Frères Soc. Anon.—Removing salt deposits from forced flow, once through steam generators. 1st October, 1954. (754994.)

28666. British Thomson-Houston Co., Ltd. —Crystal oscillator circuits. 5th October, 1954. (755087.)

28799. General Electric Co.—Electromagnetic brakes. 6th October, 1954. (754805.)

29061. Bose, J. H.—Stabilised multiplex frequency modulation receiver. 8th October, 1954. (754914.)

29237. Compagnie Générale d'Eléctricité. —Electric cables. 11th October, 1954. (754807.)

30488. Sperry Corporation. — Reflex klystron oscillator tube. 22nd October, 1954. (754811.)

31210. Le Gros, J. E.—Electric storage battery plate and method of producing it. 28th October, 1954. (755089.)

32231. Electric Storage Battery Co.—Electric storage battery plates. 8th November, 1954. (754814.)

32417. General Electric Co.—Dynamo-electric machine minding insulator. 9th November, 1954. (755193.)

33127. Allmanna Svenska Elektriska Aktiebolaget. — Annealing furnace. 16th November, 1954. (754920.)

33440. Licentia Patent-Verwaltungs-Ges. —Winding for electric machines. 18th November, 1954. (754815.)

33554. Research Corporation.—Electrostatic precipitators. 19th November, 1954. (755197.)

34204. General Electric Co.—Glow-discharge device. 25th November, 1954. (755092.)

34544. Edison Swan Electric Co., Ltd.—Pressure controlling apparatus. 29th November, 1954. (754922.)

35399. Research Corporation.—Electrostatic precipitators. 7th December, 1954. (755204.)

35794. Standard Telephones & Cables, Ltd. — Electric switching keys. 10th December, 1954. (755206.)

37119. Chromatic Television Laboratories, Inc. — Cathode-ray tube circuits. 22nd December, 1954. (755099.)

37328. General Electric Co.—Electric induction devices. 24th December, 1954. (755100.)

Train Destination Indicator

A new type of electrically operated train destination indicator is now in use at Fenchurch Street Station, Platform 4. It was designed and manufactured by Siemens Bros. & Co., Ltd.

STREET LIGHTING NOTES

One of the latest installations of Siemens Brothers' "Kuwait" street lanterns is at PRESTON. Utilising 80 W "Sieray" new warm white fluorescent tubes and instant-start control gear, the installation is arranged for three-lamp burning from sunset to midnight and one lamp burning from midnight until dawn. An extension to this scheme has been planned to make a total installation of 58 lanterns. The columns were supplied by Concrete Utilities, Ltd.

A programme of street lighting to Group A standard has recently been completed by the CHISLEHURST and SIDCUP U.D.C. Nearly 350 Mazda "Amber" sodium lanterns have been used on five of the main traffic routes through the district and shopping centres on these routes are lighted by over fifty Mazda "Diadem" 5ft three-lamp fluorescent lanterns. The scheme was designed by the U.D.C.'s engineer and surveyor, Mr. W. B. Farrow, in collaboration with the London Electricity Board, who carried out the installation work, and A.E.I. Lamp & Lighting Co. engineers.

A mercury street lighting scheme has recently been completed in WOOLWICH with the installation of 172 Mazda lanterns in six main streets. The Mazda "Sapphire" mercury vapour enclosed reflector lanterns, housing 400W lamps, are side-entry mounted on Concrete Utilities Avenue 2D columns at a height of 25ft, spaced at intervals of 120 feet. The contractors were Harland & Wolff, Ltd., Woolwich.

A new lighting system costing approximately £13,000 now illuminates the principal streets in ILFRACOMBE, Devon, 145 sodium and fluorescent lanterns having been supplied by the General Electric Co., Ltd., and installed by Cohen Bros. (Electrical), Ltd., to replace the previous gas lighting.

ROCHDALE Corporation is to seek sanction to borrow the sum of £6,200 for the conversion of street lighting from gas to sodium in Regent Street, Oswald Street, Trafalgar Street, Ramsay Street, West Street and South Street.

SUTTON COLDFIELD Highways Committee has approved plans for the installation of fluorescent lighting along trunk road A.38. The estimated cost of the scheme is £4,208.

BARNARD CASTLE U.D.C. has accepted the tender of the North Eastern Electricity Board of £2,675 for the installation of 43 sodium discharge street lighting units.

EXMOUTH Council has approved, for submission to the Ministry of Transport, a revised quotation from the South Western Electricity Board for a curtailed street lighting scheme, the capital cost of which would be £11,100.

Two months ago the Ministry of Transport and Civil Aviation asked MELTHAM Council to defer its plans for converting the street lighting from gas to electricity in view of the restriction of loan sanctions. The Council pressed the Ministry to give loan sanction for the conversion to be carried out after 1st September but the Ministry now states that the application will be considered again in "due course." The Council is to invite the divisional road engineer to discuss the matter.

CONWAY Town Council has been informed that the Ministry of Transport is not able to provide lighting on the new Conway Bridge. If the Council agrees to go forward with work itself, with a 50 per cent grant from the Ministry, an early decision would reduce costs to a minimum.

STOCKPORT Corporation is recommended to submit to the Ministry of Transport and Civil Aviation a modified scheme, estimated to cost £9,000, for the conversion to electricity of street lighting at Underbank and Hillgate.

As a start to the modernisation of main road lighting the LEWISHAM Works and Highways Committee proposes to install sodium vapour lamps along the section of the South Circular Road from Catford Hill to the borough boundary at an estimated cost of £5,000.

PETERLEE Development Corporation has approved a street lighting scheme costing £3,500 for the Dene House estate.

FARNWORTH (Lancs) Corporation is applying for £2,482 loan sanction for sodium street lighting.

FAREHAM U.D.C. is to make application for sanction to borrow £4,320 for 101 street lamps.

Swiss Imports in 1955

Switzerland's electrical import trade last year increased by roughly 5 per cent on 1954. Nearly all the principal groups shared in the advance, but radio apparatus declined slightly although it remained at about three times the value of exports. West German imports into Switzerland expanded in most lines. The accompanying table gives the values in 1955 of the leading categories with the chief supplying countries and notes of increases or decreases on the previous year. (Sw.fr.12.20=£1.)

Class of Goods	1955 Sw.fr. (000)	Inc.or dec. on 1954 Sw.fr. (000)
Accumulators	2,984	+ 540
From West Germany	1,141	+ 84
,, France	590	+ 412
,, U.S.A.	507	+ 58
Insulators	844	− 289
From Denmark	290	− 173
Meters and measuring instruments	7,452	+ 650
From U.S.A.	2,053	+ 1,154
,, West Germany	2,988	+ 432
,, U.K.	974	− 70
Telephone and telegraph apparatus	5,101	+ 253
From West Germany	1,851	− 36
,, Belgo-Luxemburg	2,893	+ 104
Radio apparatus	48,301	− 4,810
From West Germany	24,715	+ 1,851
,, France	3,138	− 12,034
,, Netherlands	5,043	+ 151
,, U.K.	2,483	− 1,017
,, U.S.A.	11,136	+ 6,490
Cables	3,682	+ 754
From West Germany	2,148	+ 973
Dynamo-electric machines	22,989	+ 6,030
From West Germany	15,629	+ 6,476
,, U.S.A.	1,867	− 287
,, U.K.	1,391	+ 251
,, Italy	1,142	− 258
,, France	1,011	− 149
Lighting and starting equipment for vehicles	7,032	+ 723
From West Germany	4,351	+ 1,882
Elec. incandescent lamps	5,518	− 279
From West Germany	1,046	− 102
,, Netherlands	1,927	− 376
,, U.S.A.	1,316	+ 166
Unspecified elec. apparatus over 500 kg.	421	− 473
From West Germany	361	− 195
Ditto 50–500 kg.	2,080	+ 266
From West Germany	1,160	+ 146
Ditto 3–50 kg.	1,989	+ 280
From West Germany	1,108	+ 387
Ditto under 3 kg.	7,962	+ 1,738
From West Germany	4,693	+ 1,038
,, U.S.A.	890	− 72

TRADE MARKS

APPLICATIONS have been made for the registration of the following trade marks. Objections may be entered up to 18th August:—

TRICON. No. 744,843. Class 9. Railway signalling and track control apparatus and parts.—Standard Telephones & Cables, Ltd., Connaught House, 63, Aldwych, London, W.C.2.

ELLSYN. No. 749,225. Class 9. Electrical apparatus and instruments; and measuring, signalling and checking (supervision) apparatus and instruments, but not including illuminated signs.—Elliott Brothers (London), Ltd., Century Works, Lewisham, London, S.E.13.

DOMINO. No. 749,839. Class 9. Electrical apparatus and instruments for use in controlling the operation of mechanical contrivances by electric current, voltage, frequency or phase.—Integra Akt.-Ges. Zurich Industrietechnische Ges., Zurich, Switzerland. Address for service, c/o Barker, Brettell & Duncan, 75 & 77, Colmore Row, Birmingham, 3.

RAPIDYNE. No. 750,774. Class 9. Electrical apparatus and instruments and parts.—Siemens-Schuckertwerke Akt.-Ges., Erlangen, Germany. Address for service, c/o Haseltine Lake & Co., 28, Southampton Buildings, Chancery Lane, London, W.C.2.

EVER READY. No. 751,952. Class 9. Flash bulbs and flash guns, all for photographic purposes.—Ever Ready Co. (Great Britain), Ltd., Hercules Place, Holloway, London, N.7.

OSPREY. No. 753,333. Class 9. Electric vacuum cleaners and parts.—Electric "O" Appliances, Ltd., 184-186, Victoria Road, Scarborough, Yorks

DYNAVAC. No. 753,379. Class 9. Electric vacuum cleaners and parts.—Dynaport Radio & Television, Ltd., Portadyne Works, 30-34, Gorst Road, North Acton, London, N.W.10.

SALADOR. No. 751,234. Class 11. Refrigerators and parts.—Hotpoint Electric Appliance Co., Ltd., Crown House, Aldwych, London, W.C.2.

CONTRACT INFORMATION

Accepted Tenders and Prospective Electrical Work

CONTRACTS OPEN

Where "Contracts Open" are advertised in our "Official Notices" section the date of the issue is given in parentheses.

Australia.—22nd August. Victorian Railways. Bare copper conductor. (E.S.B. 19049/56. Ten/20494.)*

10th September. Electricity Commission of New South Wales. Outdoor circuit-breakers and current transformers. (E.S.B. 19431/56. Ten/20587.)*

Belgium.—17th August. Telegraph and Telephone Administration. Electrical apparatus and equipment including repeaters, commutators, telephone bells, plugs, switches, condensers, coils, various types of cord, etc. (E.S.B. 19008/56. Ten/20510.)*

Burma.—16th August. Union Purchase Board. Sixteen 6 kW generating sets. (E.S.B. 19318/56. Ten/20522.)* 17th August. 7,000 electric lampholders. (E.S.B. 18829/56. Ten/20502.)* 10,000 coils of electric wire. (E.S.B. 19290/56. Ten/20511.)* Electrical fittings and fluorescent tubes. (E.S.B. 18831/56. Ten/20551.)* Underground cable and boxes. (E.S.B. 18828/56. Ten/20513.)*

Cambridge.—1st September. City Council. Electric lamps for one year from 1st October next. City engineer, Guildhall.

Costa Rica.—20th August. Instituto Costaricense de Electricidad. 100 10/15/25/27·5 kVA transformers. (E.S.B. 19435/56. Ten/20572.)* 21st August. 1,680 fuse boxes or cut-outs. (E.S.B. 19436/56. Ten/20571.)* 22nd August. 5,500 insulators and 2,500 spikes. (E.S.B. 19437/56. Ten/20581.)* 23rd August. Copper cable and wire. (E.S.B. 19438/56. Ten/20582.)*

India.—22nd August. Madhya Pradesh Electricity Board. Power line carrier current communication equipment and v.h.f. radio equipment. (E.S.B. 18888/56. Ten/20516.)*

London.—31st August. Metropolitan Borough of Lewisham. Street lighting equipment. (See this issue.)

New Zealand.—25th September. General Post Office. 3,470 lampholders and 2,548 cable sockets. (E.S.B. 19268/56. Ten/20520.)* Switchboard wire. (E.S.B. 19470/56. Ten/20565.)*

Pakistan.—21st August. Department of Supply and Development. 4,132 electric switches. (E.S.B. 19451/56. Ten/20548.)*

4th September. Posts and Telegraphs Department. Heat coils and switchboard lamps. (E.S.B. 19130/56. Ten/20501.)*

Portuguese East Africa.—8th November. Ports, Railways and Transport Department, Lourenço Marques. Two 660 kW generating sets. (E.S.B. 19192/56. Ten/20500.)*

United States.—30th August. Corps of Engineers, U.S. Army. Wire and cable for Dallas Dam powerhouse. (E.S.B. 18535/56. Ten/20539.)*

ORDERS PLACED

Ashton-under-Lyne.—Corporation. Recommended. Electrical wiring in houses at Neal Avenue (£1,072).—N. Plant.

Calne. — Corporation. Recommended. Supply and erection of 23 reinforced concrete street lighting columns, with lanterns and 140 W sodium discharge lamps and auxiliary gear, on a portion of the London-Bristol trunk road A.4 (£3,181).—Revo Electric Co.

Stamford.—Peterborough and Stamford Hospital Management Committee. Electrical rewiring for the Stamford and Rutland Hospital (£12,490).—Witcombe & Blackwell.

Stockport.—Corporation. Accepted. Electrical installations in 40 flats in the York Street clearance area (£1,907).—Lindsay Crawford Engineering Co., Ltd.

Recommended. Electrical installations at the Woodlands School, Offerton (£1,395).—Piggott & Whitfield, Ltd.

WORK IN PROSPECT

Particulars of new works and building schemes for the use of electrical installation contractors and traders. Publication in this section is no guarantee that electrical work is definitely included. Alleged inaccuracies should be reported to the Editors.

Amersham.—Factory and offices; Dewhurst & Partner, Ltd., Inverness Road, Hounslow.

County school; A. E. A. Prowting, Ltd., builders, 127, High Street, Ruislip.

Ashington.—Extensions for 170 more beds at hospital (£128,000); Cackett, Burns Dick & McKellar, 21, Ellison Place, Newcastle-on-Tyne.

Bangor (Co. Down).—Conference hall (£120,000); Borough Council.

Barrow-in-Furness.—Office block, Duke Street, for London & Manchester Assurance Co., Ltd.; Bowden, Son & Partners, architects, 3, Adelaide Terrace, London, N.1.

Bedford.—Science block for modern school (£56,000); Harpur Trust, Harpur Street.

Belfast.—Dental hospital and school in Grosvenor Road; Northern Ireland Hospitals Authority, 44/46, Queen Street.

Billingham-on-Tees.—Houses (68) in Roseberry Road; U.D.C. surveyor, Council Offices, Haverton Hill.

Blaydon.—Factory for Churchill Gearing Co.; J. M. Angus, 3, Gallowgate, Newcastle-on-Tyne.

Brighton.—Six-storey blocks (5), and three-storey blocks (7), at Bristol Gate; G. Wimpey & Co., Ltd., The Martyrs, London Road, Crawley.

Cardiff.—Multi-storey car park in Wood Street proposed (£144,000); city surveyor, City Hall, Cathays Park.

Croydon.—Five-storey building at Crown Hill/North End corner site; Barclays Bank, Ltd., Head Office, 54, Lombard Street, London, E.C.3.

Durham.—Health centre at Peterlee (£45,000); county architect, South Street.

Edinburgh.—Proposed polytechnic college on the Merchiston Castle site (£1,000,000); city engineer, 329, High Street.

Elstree.—Development of Radnor Hall and eight-acre site for training college; Church Army, Headquarters, 55, Bryanston Street, London, W.1.

Fareham.—Houses (204), Hillson Drive; U.D.C. surveyor.

Gloucestershire.—Secondary school for girls at the Park, Cirencester, and nursery schools on sites at Cheltenham; S. E. Urwin, county architect, Shire Hall, Gloucester.

Halifax.—County primary school, Ash Tree; and extensions and adaptations of the John W. Horsfall Home for the Blind (£34,000); G. Holden, borough surveyor, Crossley Street.

Harrogate.—Houses (44), off Knaresborough Road; Wrightson & Robinson, Almsford Drive.

Hemel Hempstead.—Houses (186) at Gadebridge, for Development Corporation; general manager, Westbrook Hay, Hemel Hempstead, Herts.

Houghton-le-Spring.—Houses (715) at Burnside; A. Veitch, U.D.C. surveyor.

Kent.—Girls' secondary schools at Penge (£122,700), Cranbrook (£107,500) and Paddock Wood (£110,500); girls' grammar school at Tunbridge Wells (£122,200); and secondary boys' school at Orpington (£118,800); S. Loweth, county architect, Springfield, Maidstone.

London.—Office block, Wood Street and Gresham Street, City; Nestlé Co., Ltd., Hayes, Middx.

Flats (48), Sulgrave Road, Hammersmith; borough engineer.

Dwellings (82), Withampton Street area, Shoreditch; borough engineer.

Six-storey offices in New Town redevelopment area, Stratford; London Co-operative Society, Ltd., Central Offices, 54, Maryland Street, E.15.

Factory in Western Avenue, Acton; Aircraft Steel Structures, Ltd., 7/17, Ansdell Street, Kensington, W.8.

Two nine-storey blocks of flats, Hanbury Road, Acton; borough engineer.

Two 21-storey blocks of maisonnettes, development of Camberwell House site; F. O. Hayes, borough architect, Camberwell.

Three 11-storey point blocks of flats in Claremont Road; flats (180) in New Brent Street, and houses (64) in Belle Vue Terrace; A. O. Knight, borough surveyor, Town Hall, Hendon, N.W.4.

Middlesbrough.—Two new high schools for the E.C. (£350,000); J. G. L. Poulson, architect, 171, Albert Road.

Central works depot (£150,000); J. A. Kenyon, borough engineer.

Newbury.—Houses (40), Brummell Road; A. Blake & Sons, builders, Bath Road, Padworth.

Newcastle-on-Tyne. — Multi-storey flats near Silver Lonnen; city architect, 18, Cloth Market.

School at Montague estate; city architect.

Oldham.—Houses (96), Alt estate; James Hobson & Son, Ltd., builders, Drake Street, Rochdale.

Preston.—New fish and retail market with six-storey car park in Liverpool Street; E. H. Stazicker, borough surveyor, Municipal Buildings.

Rugby.—Flats (56) for aged persons on Abbot's Farm estate; borough surveyor, Burford House.

Slough.—Technical school in Northampton Avenue (£250,000); Bucks county architect, County Offices, Walton Street, Aylesbury.

Smethwick.—Maisonnettes and flats (28), in West End Avenue; borough engineer, Council House, Smethwick, 40.

Sunderland.—Houses (157); borough architect.

Truro.—New hospital at Treliske, for the South Western Regional Hospital Board; Adams, Holden and Pearson, architects, Gordon Square, London, W.C.1.

Werrington (Northants).—Houses (246), Church estate; Richardson Properties, Ltd., Erith, Kent.

Westmeath (Eire).—Primary school in the grounds of St. Mary's College, Mullingar (£60,000); P. Ginnell, 31, Pearse Street, Mullingar.

Whickham.—Houses (165), near Whickham Highway, for the U.D.C.; Fennell and Co., architects, Bridge End Chambers, Chester-le-Street, Co. Durham.

Wigton.—New offices for the R.D.C.; surveyor.

Worcester.—Chemistry and physics laboratory block, King's School; Maurice W. Jones, architect, 1, College Yard.

Worksop.—Flats (48), on Kilton Hill and Valley Road estates; borough engineer, Park House.

* Specifications may be inspected at the Export Services Branch, Board of Trade, Lacon House, Theobald's Road, London, W.C.1 (Chancery 4411; extension 769).